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WOOLDRIDGE, C. L. *Major Street Plan for Pittsburgh.* 514.

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MINERAL RESOURCES OF PENNSYLVANIA - - - *George H. Ashley*
DEVELOPMENT AND APPLICATION OF THE UNDERFEED STOKER *Edward Rahm, Jr.*

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MINERAL RESOURCES OF PENNSYLVANIA

By George H. Ashley*

The wealth and physical well-being of any state or nation are based on its natural resources and human labor. Human labor without the resources can accomplish nothing and natural resources without human labor are valueless. Pennsylvania is rich in that she has both the natural resources and the will to work, in very large measure. It is not that her resources are so much greater than those of her sister states but that the knowledge of her resources through public and private surveys has been coupled with a restless energy, an untiring ambition, and an unconquerable desire for achievement.

This explains why, with less than four per cent. of the coal in the country, she annually meets 46 per cent. of the country's need, and, in days gone by, met two-thirds of the country's need. With no better limestone than many of her neighbors, she annually mines one-fourth of the limestone of the country and produces one-fourth of the Portland cement of the country. She mines one-seventh of the sand and gravel used and one-third of the glass sand. She makes 60 per cent. of all the metallic paint, 84 per cent. of all the paint from slate and shale, and quarries more than one-tenth of all the stone quarried—and so on down the list. Pittsburgh coal was mined 100 years before Pocahontas coal was discovered or recognized as of value, if discovered. Though mining only half of one per cent. of all the iron ore mined in the country, she makes nearly one-half of the country's pig-iron. Because of her willingness to work she has gotten rich from Michigan iron; West Virginia gas; Brazilian manganese; zinc, and a dozen other metals or ores from the South and West; cryolite from Greenland; and silk from Cathay.

As a mineral producer Pennsylvania stands alone, head and shoulders above any of the other states, producing in 1916 more than one-seventh of all of the mineral values of the United States, and nearly three times as much as her nearest competitors. In 1918 her mineral production, not including the value of her coke, ferro-alloys or pig-iron, was nearly one billion dollars out of a total production for the country of four and two-thirds billion dollars, and adding the three manufactured products mentioned would make her total one and one-half billion, or more. In 1918 she led in the production of cement, raw clay, bituminous coal, anthracite, coke, ferro-alloys, pig-iron, lime, zinc and lead pigments, sand and gravel, slate, and stone—12 products, in all; was second in clay products, natural gas, and sand-lime brick; and third in the production of graphite.

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Pennsylvania was listed in 1916 as producing commercially 37 minerals. This list, however, included all of the different kinds of clay, for example, under one head, and so with many other minerals. If the different minerals and rocks having different characters that fit them for different uses had been listed separately, and there had been added the names of minerals mined in other years or that may be mined in the future but not mined in 1916, the number would probably have run well above 57 varieties. Under the heading of clay, for example, is included kaolin, or white clay, suitable for china; river clay suitable for common brick; flint fire-clay; shale for tile or vitrified brick; under clays of the coal measures suited for pottery, etc.

It has sometimes been asserted that Pennsylvania is self sufficient in her mineral resources. That is far from being true—much less true than of some of the other states. For example, Tennessee has nearly every mineral mined in Pennsylvania, and in commercial quantity; and, in addition, she has barite, bauxite, gold, silver, lead, zinc, manganese, phosphate, fluorite, and potash—all lacking in Pennsylvania or existing in quantities too small to supply her needs.

Coal is predominantly the mineral resource of Pennsylvania. The value of her coal produced in 1918 was almost exactly $800,000,000. Leaving out of account, coke, pig-iron and ferro-alloys, which are manufactured products and worth in 1918 over $650,000,000, the other principal mineral products of Pennsylvania are clay products, cement, natural gas, and petroleum.

As a recital of the resources of the state in the usual way, while handy for reference, is apt to be dry to listen to and is likely to short circuit from one ear to the other, I propose, with your permission, to string my facts and figures along a tale about "the house that Jack built" in Pennsylvania.

Let us assume that Jack has made a little extra money in McKeesport gas or Texas oil or in just plain profiteering, and has decided to build him a house out on a hill overlooking one of the rivers. Being a loyal Keystonian, Jack has specified in the contract that, as far as possible, all of the materials going into the house are to come from Pennsylvania, and being of an inquisitive turn of mind, Jack wanted to know where everything came from that was used, something of his state's production of that material, and in some instances how much there was left. Time will not permit going into great details regarding all of the materials, yet it will interest us to see how largely Pennsylvania could supply the materials for a house and its equipment, if called upon.

So Jack began to ask questions as soon as the cement, and sand, and gravel were hauled on the ground for the foundation. The cement, he learned, came from the Lehigh Valley district, which was the first district to make Portland cement in the United States, and to-day produces more cement than any other similar district in the world. Portland cement has been made in that district since 1869 and the district produces to-day more than one-fourth of all the cement made in the United States. The cement there, he learned, was made from Trenton limestone, which looks much like shale—in fact, it carries about one-fourth shaly matter, so that some of the mills simply grind up the rock as it is, though most of the mills have to mix in a little pure limestone, which may come from southeastern Pennsylvania or New Jersey. Cement is also made on a smaller scale in western Pennsylvania, both from limestone and slag. The annual production of the state ranges from 20,000,000 to 30,000,000 barrels, worth $30,000,000 or more.

The sand and gravel, he learned, came from benches along the Allegheny River. When the great glaciers of the Ice Age filled the upper valley of the Allegheny River, the river was flooded with waters carrying a heavy load of sand and gravel—so heavy that the channel became filled far above its present level.

Later, the channel cleared itself out, but there are still large beds of sand and gravel forming benches along the flanks of the hills. The other rivers of the state running from north to south likewise carry gravel in terraces. Indeed, during the war, when Danish pebbles for the pebble mills could not be had, it was found that the river gravels would serve this purpose, and he learned that pebbles from the Delaware River had been used to grind his cement. Pennsylvania furnishes about one-seventh of all the sand and gravel used in the country.

The cellar wall, to the ground level, was built of sandstone coming from the coal measures of Clearfield County. He learned that the coal-measure sandstones furnish a large amount of rough structural stone and a very small amount of high-class building stone. The supply in Pennsylvania is endless, as nearly every hill in the state is underlaid with sandstone, though not all of this is by any means suitable for even rough building purposes.

From the ground level to the first floor the walls were of "brownstone" from Hummelstown, near Harrisburg, where brownstone has been quarried for several generations. This is a true brownstone of Triassic Age similar to the Connecticut River brownstone, which in past generations was the mark of wealth in New York and other eastern cities. The waste stone at Hummelstown, he learned, goes into sand-lime brick. Inquiring about the mortar colors, he learned that they came from Pennsylvania—being made up from a mixture of iron oxid, ground slate or shale, and culm from the coal washeries—and that this state produces about one-third of all made in the United States.

The first-story wall was of granite from southeastern Pennsylvania. Much of that part of the state in the Philadelphia district, he learned, is underlaid with schistose rocks or gneisses of little or no value as building material; but here and there the grain of the rock becomes more regular, so that some granite of very fair quality is quarried. In 1918 nearly one-third of a million dollars' worth was cut, part of it utilizing large surface rocks of granite. Terra cotta tile was set in the wall between some of the windows. This tile, Jack learned, was a Pennsylvania product with an average value of $500,000 yearly.

The second-story wall was built of face brick backed with common brick—both Pennsylvania products. In fact, Pennsylvania stands second among the states in the making of clay products, which in 1918 totalled over $50,000,000 worth, including everything from common brick to cream-colored china. A large share of both the face brick and common brick come from the clays and shales of the coal measures and are made in Allegheny and Beaver counties, although Armstrong County leads in the production of front brick and Philadelphia County in the production of common brick. In 1918 Pennsylvania made $5,000,000 worth of common brick and $1,500,000 worth of front brick.

Inquiring about the lime used in building the house, Jack learned that Pennsylvania produces from one-third to one-fourth of all the lime made in the United States, the bulk of it coming from Blair, Center, Chester, Lancaster, Montgomery, and York counties. Over $6,000,000 worth is made yearly.

The roof, of course, was covered with slate, coming from the Slatington region of Lehigh County. Jack was interested to learn that Pennsylvania supplies about one-half of all the slate mined in the United States. About one-half of the state's product goes into roofing slate and the rest into structural and sanitary material, blackboards, electrical fixtures, school slates, etc. The slate comes from a broad belt of shale extending across the state from the Delaware River to Franklin County, or from a small area in York County. The slate is the result of the metamorphism of the shale which in those places is jointed across the bedding by pressure. It is the joint faces that make the slate faces. The state produces from $2,000,000 to $3,000,000 worth of slate yearly.

The floors and partitions of hollow tile, he knew, came from the state and he learned that it produced more than $1,000,000 worth yearly.

Jack had decided that the front hall must be in marble, and he had certain ideas of a pattern he wanted worked out in the marble wainscoting. He had some difficulty in finding what he wanted, for Pennsylvania is not a large producer of marble, but after a personal canvass of the field he satisfied himself with a variety of marbles from Chester, Montgomery, and Delaware counties, including some serpentine in the pattern. The front steps, window sills, and outside door sills were of limestone, and Jack was interested to learn that limestone quarrying formed one of the state's largest industries, though the amount of dressed building limestone is insignificant, the bulk of the limestone going into flux, crushed stone, and lime.

As Pennsylvania makes nearly $2,000,000 worth of sewer pipe yearly, Jack found no trouble in getting his supply from close by.

Then for a time the house was turned over to the heating engineers, the plumbers and electricians, and Jack was kept busy asking questions. First, he learned that iron, which all of them used, has been mined from ore scattered over all parts of the state, but that to-day it is mined in only a few places. In the western part of the state, iron ore occurs as a thin layer from six inches to one foot thick on top of the Vanport or ferruginous limestone, and, as clay iron stones scattered in shales. In the central part of the state it occurs as hematite in the Clinton horizon. The Clinton stretches as a thin band of iron ore from New York to Alabama. It is the principal source of the iron ore of the Birmingham district and furnishes no small part of the iron of Tennessee and Virginia.

The central and eastern part of the state originally contained large accumulations of limonite in pockets where the iron had weathered out of limestones in which it is believed originally to have occurred. Such pockets of ore were common in all of the limestone valleys of central and southeastern Pennsylvania and contained the iron that led to the establishment of many of the iron furnaces in that part of the state, some of which are still alive and going.

In southeastern Pennsylvania are a few deposits of magnetite, notably at Cornwall, where 500,000 tons, or more, are mined each year from a great open pit nearly one-half mile long and a quarter of a mile wide and extending to 250 feet below the original top of the hill. An interesting feature here is the fact that two companies are working in the same pit. One of them, however, under an old contract, may mine only so much ore as is necessary to run one furnace, "as long as grass grows and water runs." You may guess that that one furnace is no midget.

Until 1880, Pennsylvania led in the production of iron. How widespread it was may be judged by the location of the present furnaces and the many small furnaces which have long ceased operations scattered from one end of the state to the other. How much of the iron remains in the ground is a problem for the new State Geological Survey to solve. The Cornwall mines have been working since 1741 and will be working for another generation at least. There is a general impression that the native ores, except at Cornwall, had become nearly exhausted when the Michigan ores began to enter the state. As much of the iron ore of the state has been a surface accumulation produced by the weathering of limestone, it is possible that this is true, though it is certain that there are still deposits that it will pay to work in the future.

But as one thing leads to another, so the iron industry led to many others. Thus, iron smelting requires a flux, and that has led to the mining of between $4,000,000 and $5,000,000 worth of limestone for that purpose, the supplies coming mainly from the Vanport limstone along the Beaver River, the Trenton limestone of Blair and Huntingdon counties, and limestone of York, Lancaster and other counties of southeastern Pennsylvania. The iron industry also demands fire-brick, so Jack learned that Pennsylvania made, in 1918, $24,000,000 worth of clay fire-brick and $13,000,000 worth of silica fire-brick. The clay fire-brick is largely made from flint clay which is fairly abundant in Clearfield and a number of adjoining counties. To this should be added over $1,000,000 worth of ganister for furnace linings. Ganister is derived from the white sandstones that outcrop so prominently along some of the ridges seen from the train in traveling along the Juniata River. At present, most of the ganister is made by grinding up the large body of float on the face of these ridges. The Medina sandstone, at the base of the Silurian has been found most suitable. Iron also calls for graphite crucibles, so Pennsylvania meets the need by producing yearly about 1,000,000 pounds of graphite which comes from a small area northwest of Philadelphia. Still another industry created by the iron industry is that of supplying molding sand. This comes mainly from the valleys of the Allegheny, Beaver and other rivers of the state. In 1917, this brought in the nice little sum of $700,000. Then there is the coke business. In 1918, Pennsylvania produced $160,000,000 worth of coke, most of it coming from the area in which the Pittsburgh coal bed is mined, though not all of the Pittsburgh bed will yield satisfactory coke. Connellsville is considered the type locality, though satisfactory coke is now coming from the Klondike region of western Fayette County, from Greene County and southeastern Washington County. There is also considerable coke made in other parts of the state, as at Johnstown, and Punxsutawney. A side line connected with the iron industry is the making of ferro-alloys needed in the production of special steels. Though Pennsylvania has to import the material for these alloys, she has taken a leading place in their manufacture. Thus of 14 places in the United States making ferro-manganese in 1916, 8 were in Pennsylvania; 7 of 12 places making spiegeleisen were in Pennsylvania; 1 out of 10 making ferro-silicon; all 3 of those making ferro-tungsten and all of those making ferro-vanadium, as well as the only place making ferro-molybdenum. The total value of the ferro-alloys in the United States is over $50,000,000 and Pennsylvania's share is well over $30,000,000.

But the iron industry in Pennsylvania to-day takes its significance not from the amount of iron ore being mined, but from the amount of steel and pig-iron being made. In recent years, Pennsylvania has been making nearly $500,000,000 worth of pig-iron yearly.

When Jack tackled the plumber, he opened up an interesting field, though of very different magnitude from that of the iron users. He found that the plumber called for lead; enamel ware made from china clays, and using feldspar; soapstone to be used for laundry tubs; nickel for enameling fixtures; and so on.

Lead is one of the materials which Pennsylvania has produced in very small quantities. A little was produced in 1916, and while she produces very fine cabinet specimens, to-day, she can hardly be classed as a competitor with Joplin, Mo. So Jack found his plumber had gone outside of the state to get lead. He had also gone outside of the state to get soapstone from Virginia, though some soapstone is found in Pennsylvania. But the enameled ware came from Beaver County, being made from the Lower Kittanning clay, and the necessary feldspar and silica for mixing came from Pennsylvania. Pennsylvania does not produce much feldspar, amounting to only from 6000 to 10,000 tons a year. This comes from the southeastern part of the state where veins of igneous rock break their way through the other rocks. Feldspar mainly goes to points outside the state such as Trenton, N. J. and East Liverpool, Ohio, where it is mixed with china-clay in the making of china and pottery. Pennsylvania, however, does produce some china clay or kaolin. This comes from the area of the South Mountains in Adams County and Cumberland County and from Chester and Delaware counties. Much of this clay goes into paper but some of it is used for fine china or enameled ware.

The nickeled fixtures recalled the fact that Pennsylvania in the long ago was a producer of nickel. Nickel was discovered in 1732, at Gap, Lancaster County, where the deposit was first worked as a copper mine. After lying closed for many years, it was again opened as a nickel mine and from 1863 to 1888 was the only nickel mine on the American continent. It was opened again in 1902 for a short time. The ore carries some cobalt as well as the copper. It is the belief of some that there is still much nickel existing at this point and it may be again the source of an industry.

When Jack looked up the electrician, he found him using Pennsylvania copper as called for in the specifications. Little or no copper ore is being mined in the state to-day although 115,000 pounds were obtained in 1917 and 34,000 pounds in 1918. Native copper is found in the South Mountain, Adams and Franklin counties, and copper pyrite occurs in a number of the southeastern counties of the State. "Shows" of copper are reported from Sullivan, Lycoming, Bedford and other counties. Most of the copper produced in the state, however, comes from the copper-bearing pyrite concentrates from the Cornwall iron ores. These concentrates are prepared by electrical separation at Cornwall and shipped to Philadelphia at which point the pyrite and copper are separated. A little native copper has been found in the past in the Cornwall iron ores. In addition to the copper for the wiring, the electrician has need of many substances for insulation. Part of these are of porcelain and others involve other materials, of which mica and asbestos may be mentioned here. Pennsylvania has been a producer of mica on a small scale for many years, the production coming from the southeast counties of the state. Asbestos has been mined on a small scale in Delaware County.

The plastering of the walls again introduced the subject of lime, and Jack learned that Pennsylvania produces no gypsum, which was needed by the plasterers.

Then came the windows. Jack was interested to learn that Pennsylvania produces more than one-third of all the glass made in the United States. Pennsylvania glass is made, in the main, from Pennsylvania sand. There are two principal sources, the most important located in central Pennsylvania where the sand used is derived from a relatively thin bed of sandstone known as the Oriskany sandstone. This sandstone zigzags its way across the State from New York to Maryland and is characterized in many places by being over 99 per cent. pure silica. The production in Pennsylvania is mainly from Huntingdon and Mifflin counties. The next most important area lies in the upper Allegheny valley in Elk, Forest, Venango, and Jefferson counties and some glass sand is mined in Fayette and Westmoreland counties. In all of these latter places, the sand is obtained from the Pottsville sandstone at the base of the coal measures.

In response to his inquiries of the painters, Jack learned that Pennsylvania is a great paint-making state. The pigment is made, in part, from mineral pigments, whether low-grade ores of iron or of chromium, or by grinding up shales or other materials of that kind; or, the pigment is obtained from the refining of zinc and lead ores. Most of the mineral pigments are obtained from the eastern end of the state, drawing especially on carbonate of iron ores. Of peculiar interest is the mining of chromite in Lancaster County close to the state border. Chromite or chromic iron ore has in the past been mined in Chester and Delaware counties also, but at present the mine in Lancaster County is the only one operating. This ore is used mainly in the manufacture of chrome yellow, orange, and green pigment. Among the other materials used in the manufacture of paint in the state are graphite, soapstone and talc. Some soapstone occurring near Easton is used in the making of paint.

One of the painters told Jack that Pennsylvania had been one of the first states to mine and smelt zinc. The mines were located in the Saucon Valley of Lehigh County, the ore being in the main a gray sphalerite. Great difficulty was encountered in draining the mines due to the fact that the crevices in the lime allowed water from the whole valley to flow into the pits which were about 300 feet deep. To handle the drainage a very large pump called "The President" was installed. A proposal to use the water as a supply for Philadelphia met the objection that, if the water were sold, the mining company would at once be liable for damages to all the land owners of the valley whose wells they had drained.

To-day there art three large zinc smelters in the state, from which the state is supplying a large amount of zinc paints. The zinc ores used come from outside the state.

As the house neared completion, Jack became interested in the fixing up of the yard. He found that the driveway for the automobile was being paved with trap rock, an igneous rock abundant in the southeastern part of the state where it is extensively quarried for road making, it being the most durable rock known for that purpose. Across the sidewalk and in the lower slope of the drive, paving bricks were used, again drawing on the large clay products industry of the state. In 1918, Pennsylvania made over $1,000,000 worth of vitrified brick, using for that purpose, in the main, shales occurring in the coal measures.

Then came the problem of fuel for heating. Was he to use coal, oil or natural gas? Jack had heard conflicting stories regarding the relative cost and efficiency of these three fuels, intermingled with rumors that the supply of all three was being reduced or approaching exhaustion and that if he put in natural gas or oil, he might be compelled within a few years to take them out. I need not tell you what he learned about their relative cost and efficiency, but will confine myself to what he learned with reference to the present condition of supplies and the future outlook.

Natural gas, he learned, had been put to practical use in New York State almost 100 years ago, but in this state it was first utilized about 1872. In 1883, pipe-lines led gas from the Murraysville field to Pittsburgh and, from then to the present time, the use of gas has steadily increased. He learned that Pennsylvania wells had their largest production in 1906 and had since declined. However, Pennsylvania's needs and demands have, for many years, far outrun her own production and the difference has come mainly from West Virginia; but, in 1917, West Virginia reached her maximum production which to-day is declining rapidly, so that it became evident to him that either Pennsylvania must reduce her demands or run short. He found that industrial users were already being cut off in cold weather in favor of household users and he found distinct indications that householders were likely in the future to be restricted to the use of natural gas in efficient cook stoves, hot-water heaters adapted for burning natural gas, and such other incidental uses as cannot well be supplied by coal. Inquiring of the State Geologist, he learned that while the principal sources of natural gas had already been exploited, the old fields would still yield much gas, and many minor new fields will probably be found so that some natural gas will probably be used for one or two generations or even more to come, but that a study of all the conditions indicated that the output was likely to decline steadily.

He learned that the gas field now existing on the south shore of Lake Erie is almost certain to expand southward across Erie and Crawford counties drawing gas from the Portage shale and Medina or "Clinton" sand. He also learned that there is a possibility of their some day reaching the Medina sand under Chestnut Ridge or Laurel Hill. Much gas may yet come from the eastern part of the gas field though much fruitless drilling there has discouraged prospecting.

The oil situation was found to be much like that of natural gas. Oil as the source of an industry dates from the Drake well in Titusville in 1859. It reached its maximum in the state with the discovery of the McDonald field in the early nineties when the state's production exceeded 30,000,000 barrels. From that time it declined to less than 8,000,000 barrels in 1912, and has since remained about stationary at between 7,000,000 and 8,000,000 barrels. It is possible that under the stimulus of present prices, the production for 1920 will exceed 8,000,000 barrels.

Oil in Pennsylvania differs from natural gas in that it is believed that few, if any, really new fields are likely to be found. An oil and gas map of the state shows that production is confined to a narrow belt crossing the state diagonally from Bradford to the southwest corner, but that oil is confined almost entirely to the western half of that belt; so that, while there may be many untested areas, both east, northwest, and south of this belt that may yield gas, the only hope for more oil appears to lie in drilling untested areas within the field already developed. These will doubtless yield a large amount of oil in the future and occasionally a gusher will be struck, such as the one recently drilled in northern Greene County, but, more and more, Pennsylvania must depend on outside sources.

One hopeful phase of the oil situation, he found in the rejuvenation of some of the old fields formerly supposed to be nearly exhausted. Thus, in the Bradford field, the judicious introduction of water to the sand is forcing out of the rock more oil than was obtained originally, so that about sixty new wells a month are now being drilled in that field long thought to be approaching exhaustion. In other fields water does not work, but the Smith-Dunn process, using compressed air is being tried. It, therefore, appears that some oil is likely to be produced in Pennsylvania for many years, though the amount will be small compared with the demand in the state.

A study of the coal situation took a great load from the mind of our friend Jack, for he found that—notwithstanding the fact that for years Pennsylvania supplied two-thirds of the country's need for coal and still supplies nearly one-half of it—we had used up only about one-third of the anthracite and only about one-twentieth of the bituminous coal of the state; and that, so far as his new house was concerned, he did not need to lie awake nights, worrying for fear sometime in the future he would be too cold to sleep.

However, he was interested to learn from the State Geologist that the time would come when Pennsylvania would be at a disadvantage with some of the other states because while she still would have plenty of coal, it would all be in thin beds and expensive to mine, for Ohio, Indiana, Illinois and some other states had been sitting on their own apples while eating ours because ours were better, and they would still therefore have an abundance of cheap coal. The thick and cheaply mined coal of Pennsylvania comes either from the Pittsburgh bed or from pockets of thick coal in other beds. The Pittsburgh bed is uniformly from five to nine feet thick, and in the past has supplied the bulk of the coal mined—in recent years about 100,000,000 tons of the 170,000,000 tons of bituminous coal mined in the state. Some of the smaller basins, such as the Greensburg and Uniontown, will hardly last more than 20 to 25 years. The estimate given Jack of the total amount of Pittsburgh coal remaining in the ground was approximately 8,000,000,000 tons of which one-half lies in Greene County; and, at a rate of consumption of 100,000,000 tons a year, that bed would last for 80 years.

The pockets of thick coal outside of the Pittsburgh bed are rapidly being depleted, and mining is more and more shifting to the thinner beds. Indeed, he further learned that already most of the field outside of the Pittsburgh bed is known as the "thin-bed district." The change becomes apparent with a study of any district mining the Allegheny or "lower coal measure" coals. For example, some 15 years ago, the State Geologist made a study of the coal in the Punxsutawney district which includes a number of large mining areas, and he found that originally 65 per cent. of the coal had been less than three feet thick, 25 per cent. had been from three to four feet thick, and only 10 per cent. had been over four feet thick. At the time this study was made (1905) nearly all the mining in the district was on coal beds four feet thick or more. In 1916, statistics showed that 40 per cent. of the coal produced that year came from beds four feet thick, or more; 57 per cent. from beds three to four feet thick and three per cent. from beds less than three feet thick. It was pointed out to him that it was readily seen that 15 years more would probably see the disappearance of all coal four or more feet thick in that district, and all mining would be on beds less than four feet thick, and instead of three per cent., as in 1916, quite possibly from 25 to 50 per cent. will be in beds less than three feet thick. Fifty years ago mining in the Moshannon field was on the Moshannon bed where the coal was 4.5 feet thick, or more. Coal less than four feet thick was left as unminable. To-day the same bed is being mined where only 30 inches thick; as all of the thick coal is gone, including areas left in the early mining. So that, in general, while Jack found that Pennsylvania was going to have coal enough to last for several hundred years, he was led to conclude that 100 years would probably see the exhaustion of all of the thick and cheaply mined coal in the state.

Pennsylvania is estimated to have had originally 21,000,000,000 tons of anthracite and some 112,000,000,000 tons of bitumrinous coal. The anthracite field has been computed as 484 square miles in extent. In 1892, A. D. W. Smith computed that 2,250,000,000 tons had been mined or lost, and estimated that there was still to be gained over seven times as much coal has had already been mined. In 1910, M. R. Campbell estimated that the production and wastage had exhausted more than 4,000,000,000 tons. From 1911 to 1920, inclusive, the production of anthracite will be not far from 825,000,000 tons. Allowing as much more for wastage, would make the total exhaustion approximately 6,000,000,000 tons or about 30 per cent. of the total. It may therefore be estimated that anthracite will be produced for another 100 years, at least, though the cost of mining it is bound to increase steadily.

Anthracite mining led in Pennsylvania until 1889 when for the first time the amount of bituminous coal mined exceeded the amount of anthracite. In 1909 the total amount of bituminous coal mined reached and exceeded the amount of anthracite mined. The totals at the close of 1910 were 2,180,323,469 tons of anthracite and 2,251,737,097 tons of bituminous. Since 1910 approximately 1,620,000,000 tons have been mined—a total of about 3,870,000,000 tons to the end of 1920. Though more bituminous coal has been mined the total exhaustion probably does not exceed 6,000,000,000 tons, or the same as that of anthracite, leaving in the ground yet to be mined 106,000,000,000 tons which should ultimately yield not less than 75,000,000,000 tons of coal for use, and perhaps more. If we continue to mine 150,000,000 tons a year, the bituminous coal in Pennsylvania should last 500 years. But Jack was told not to forget that much of this coal is in very thin beds difficult and expensive to mine, and that much of it may be rendered unminable by the previous mining of thick lower beds.

Then came the problem of gasoline for his automobile, and he was interested to learn that Pennsylvania is producing a large amount of gasoline from its natural gas in addition to that derived by the distillation of petroleum. He found further, that in the early days, before the drilling of the Drake well, Pennsylvania supported a large industry in distilling oil from oil shales or cannel coal, and that a recent study of the state's reserve of oil shales showed that while it is not large, a small amount of gasoline would be derived in the future from these oil shales and cannel coals. Unfortunately, the thick beds of oil shales which outcrop in Ohio, Indiana, and Kentucky, are of Devonian Age, and in western Pennsylvania are far below the coal measures, coming to outcrop only in central Pennsylvania, where they are so highly folded and so metamorphosed that distillation tests show that they contain no oil. He learned therefore, that with the depletion of Pennsylvania's petroleum beds, Pennsylvania will become almost entirely dependent on outside sources for motor fuels. He was, however, gratified to learn that some of the states further west, and particularly those west of the Mississippi River contain such large beds of oil shales that he need have no fear but that oil could be obtained for his motor car, at least as long as he lived, and at a price probably not greatly above present prices.

On inquiring what would be used if natural gas disappeared, he was told that some of the large natural gas companies were already preparing to take over the needs of their customers with artificial gas, which would, of course, throw an additional burden on the state's coal reserve. He found, however, that there was a distinct tendency toward the use of by-product gas obtained in making by-product coke and much talk of a time when most of the high volatile coals would not be used raw but first be run through retorts so as to obtain from them the valuable by-products after which the residue, now rendered smokeless, would be used in place of the raw coal. Of minor interest in this connection, he learned that bog iron ore was being mined in the Upper Allegheny valley for use in the treatment of artificial gas, where it serves to abstract the hydrogen sulphid. He also learned that a beginning had been made on the study of the treatment of mine waters, primarily to prevent stream pollution, but resulting in a material that was better even than bog iron ore for purifying artificial gas or by-product gas. Time will hardly permit going into the details, but it might be worth while to mention in passing that friend Jack found china made in Pennsylvania was in part made from Pennsylvania clays; that he could buy mineral waters from mineral springs of Pennsylvania, this state supplying over 1,500,000 gallons yearly; that in the olden days he might have purchased salt for his table from the salt wells in Allegheny County, in upper Allegheny city, and that for a time bromine was made from these salt wells, to be taken "the morning after." Indeed he learned that the first bromine extracted in this country had been obtained at Freeport.

Inquiring about soap, he learned that the state had a very large and growing industry in the manufacture of sulphuric acid, which is being made at different places from Philadelphia to Donora; that a variety of polishing powders are among Pennsylvania products, some of these being made from tripoli, some from ground sand; and that he could get talcum powder made from Pennsylvania talc. He learned that a little gold and silver was being extracted in Pennsylvania from lead and zinc ores, the ores, however, coming from other states. He learned, however, that traces of gold and silver ores had been found at many places in southeastern Pennsylvania though no commercial deposits had ever been found. Traces of gold are "discovered" in the river sands under Philadelphia about every so often.

Finally Jack found that if his desire for gems was not extravagant, he might satisfy it with gems from Pennsylvania hills.

DISCUSSION.

Mr. J. B. Mandeville:* How far east does that oil and gas belt run, and what are the possibilities in Clearfield County?

George H. Ashley: I have been very hopeful until recent years that Clearfield County would have a lot of gas in it. Near Carrolton they have been getting gas for twenty years or more, and are getting 20,000 cubic feet a day yet. On the western flank of the Chestnut Ridge south of Punxsutawney they have been getting a little gas since the eighties and are still getting it. I have felt that these facts have indicated that the top of the Chestnut Ridge should show some gas, but it is my understanding that drilling on top of the ridge in the last ten years has been without results. Some recent drilling on the crest of the Laurel Ridge anticline north of Houtzdale failed to find gas, though that region is very badly faulted, which may have affected the results.

Mr. J. B. Mandeville: Was it drilled deep enough over there?

George H. Ashley: I am not quite sure of that. Here is the problem. From northeast to southwest these sands are about the same distance apart. But from west to east the beds between the Pittsburgh coal and the "Clinton sand" thicken from 4000 feet in central Ohio to over 13,000 feet on the Allegheny front in Blair County, Pa. I have questioned whether drillings in Clearfield County have reached the Speechley sand. In fact, taking the thickness of the rocks as we know them on the Allegheny front, it appears quite possible that the drilling east of the Chestnut Ridge has not reached the Speechley sand, though at Canoe Creek and Marion Center, it appears to have reached productive sand, which detailed studies may prove to be the Speechley. Of course the drillings at McCance went through the horizon of the Speechley sand, but without getting gas in it. My hope of large gas production in that area has rather gone glimmering, but it has not disappeared yet, because deeper drilling may yet reveal much gas. I cannot understand why there should be gas on the western flank of the Chestnut Ridge, and where you are drilling it, and not on the crest.

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*Chief Engineer, T. W. Phillips Gas & Oil Co., Butler, Pa.

MR. J. B. MANDEVILLE: We got a good well opposite Marion Center in Indiana County. That may be east or directly south of where you were speaking of near Punxsutawney. We got a very nice well and about nine dry wells. But we are interested in east of that point.

GEORGE H. ASHLEY: I hope you will try out some of those places because I shall not be satisfied that there is no gas there until it has been fully tested.

MR. J. B. MANDEVILLE: Do you think you will modify your calculations any on the depth of the Speechley sand there?

GEORGE H. ASHLEY: The rocks are all thickening in that direction. The thickening does not show very well in the drillings. We think we recognize the Salina or "salt" formation in the McDonald well. Comparing the thickness of the rocks between the Pittsburgh coal and the Salina in that well with the thickness of the same rocks in the Allegheny front in Blair County, it will be seen that the thickening has been very large. From such studies as have been made of the McCance record, it looks as if the rate of thickening is greater east of that well than on the west.

MR. WILLIAM E. SCHMERTZ:* What is the future outlook for natural gas near East Liverpool, Ohio?

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*Assistant Manager, Bureau of Inspection, Jones & Laughlin Steel Co., Pittsburgh.

George H. Ashley: Around East Liverpool most of the sands have run out. The only producing sand in that area is the Berea, unless drilling reaches the Medina or Oriskany sands, which may prove to contain either oil or gas. So I should say that it is not very favorable. You know what drilling has been done there. Some oil and gas has been found, but, as I remember the field, there has been very little large production in the past and a good many very small producers.

DEVELOPMENT AND APPLICATION OF THE UNDERFEED STOKER

By EDWARD RAHM, JR.*

DEVELOPMENT

In the presentation of this paper we shall endeavor to treat briefly of underfeed stokers, both of the multiple-retort and the single-retort type, and shall confine ourselves to a history of the development of the art in the United States of America, and to the types with which the writer is most familiar.

No particular comparison is to be made of the relative value of the different types of underfeed stoking equipment, but our attention will be directed impartially to the various refinements and improvements in the art of stoker manufacture as they occurred from time to time.

To Mr. Evan William Jones, of Portland, Ore., is due the credit for inventing the first successful underfeed mechanical stoker. The circumstances leading up to the invention are of more than passing interest and we shall endeavor to recount them briefly.

In the state of Oregon, wood, particularly Oregon fir, was more easily obtainable than any other fuel for firing purposes and was universally used. This wood is high in moisture and retains it longer than most woods, so it is easy to appreciate the necessity for some means of quickly and effectively drying it before using it as a fuel.

At this time, in 1888, Mr. Jones was president of the Union Iron Works, of Portland, and his mechanical skill was well known. Thus, it came about that when the paper-mills near Portland found it impossible to keep up steam with the green wood available as fuel, they referred the problem to him and requested that he devise some scheme whereby the wood could be dried at least partially before it was used.

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*Sales Engineer, Under-Feed Stoker Company of America, Pittsburgh.

After giving the subject considerable thought, he decided that the only practicable plan was to dry the fuel with the heat used to steam the boilers. It was also decided that this result could be best accomplished by introducing the fuel from beneath the fire, carrying the fire on top of the fuel itself instead of on grates, as was being done. He undertook to do this by means of levers, but it was not satisfactory and the steam ram was finally developed for the purpose. The supports for the wood, which was of standard cord length (four feet), consisted of solid iron plates, except the inclined rear portion of the furnace where grates were used. See Fig. 1.

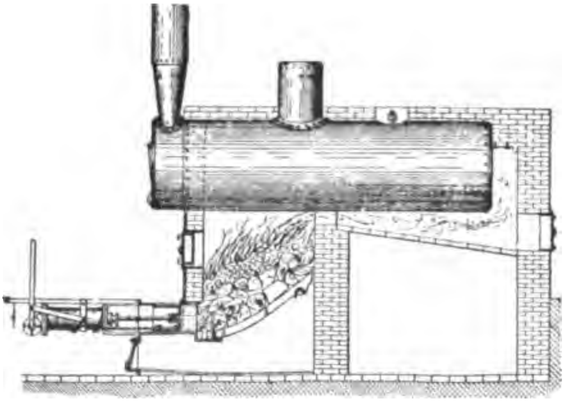

Fig. 1. The First Underfeed Stoker.

In starting up a furnace, wood was piled in by hand and the fire was kindled on top of the pile. As soon as the steam pressure was high enough to operate the ram, a fresh supply of wood was introduced, as needed, by successive strokes of the piston. The results obtained were better than had been expected. An excellent fire was maintained in the furnace, always at the top of the fuel bed, and the intense heat served to dry the wood beneath. A considerable quantity of gas was driven off in the drying process which passed up through the fire and was consumed. A small additional amount of heat was thus obtained, but the chief advantage of the system lay in the dry fuel obtained before it reached the zone of combustion. No difficulty at all was experienced in holding steam pressure, even with the greenest of wood.

During the experiments with this first stoker, the fundamental principle of underfeeding was discovered—i. e., the introduction of the air above the fresh or green fuel, but below the incandescent fuel bed and at a point where the volatile gases are being driven off by the heat from above. A complete mixing of gas and air is thus brought about before the mixture reaches the zone of combustion where it is consumed. If the amount of air supplied is correct, the result is complete, and therefore smokeless, combustion; also, the heat of the gases is utilized, which in ordinary hand-fired furnaces is nearly all wasted. At this time no particular thought was given to proportioning air and fuel. Both were cheap and the only consideration was steam and plenty of it. If the fireman kept the pressure up, no one worried so very much about the pounds of water evaporated per cord of wood.

Mr. Jones realized that a very limited field was available for a mechanical stoker designed solely for the use of wood, so he set about adapting it to the use of bituminous coal. The latter contains a high percentage of volatile matter and it seemed quite natural that the plan that had worked so successfully with wood would be equally satisfactory with coal.

Having designed a coal-burning underfeed stoker that he thought would operate successfully, he obtained permission from the Portland Cable Railway Company to equip two of its furnaces. The sloping bottom support for the bed of fuel was essentially the same as that used for wood, as shown in Fig. 1, and a steam ram was used in both cases to introduce the fuel.

The necessary air for combustion was supplied by an independent engine-driven blower. From the boiler, the air passed to a wind box located on either side of the retort and thence through the tuyeres placed below the zone of combustion into the furnace. The tuyeres extended from one end of the retort containing the coal to the other. Fearing that these tuyeres would burn out rapidly, an attempt was made to protect them by providing two pipes which were cast in the upper portion of the tuyere blocks and through which water was circulated.

It was soon discovered that the pipes containing the water were destroyed in a very short time, while the tuyeres, protected by the air which was continually forced through them, were practically indestructible. The use of the pipes was, of course, abandoned.

Various changes occurred after the operation of the first model, in the shape of the retort, in the depth of the tuyere blocks, and in the arrangement of a secondary means of propelling the coal after the ram had pushed it inside the furnace. Instead of using side grates, as had been the practice on previous models, a narrow dead plate was substituted. Air boxes were abandoned and the entire ash-pit was used as an air chamber. The standard type of Jones underfeed mechanical stoker was finally evolved as it is now made and has been made for over thirty years.

We would like to call attention briefly to the design of this stoker as it is in use to-day. Fig. 2 shows a longitudinal section through the furnace and stoker. Steam admitted behind the piston, forces the piston and ram forward, carrying a portion of the coal in the hopper to the retort. The pusher rod moves with the ram to carry coal forward in the retort and thus secures an even distribution of the fuel in the furnace. Attention is called to the fact, clearly shown in this view, that no moving part is in contact with the fire.

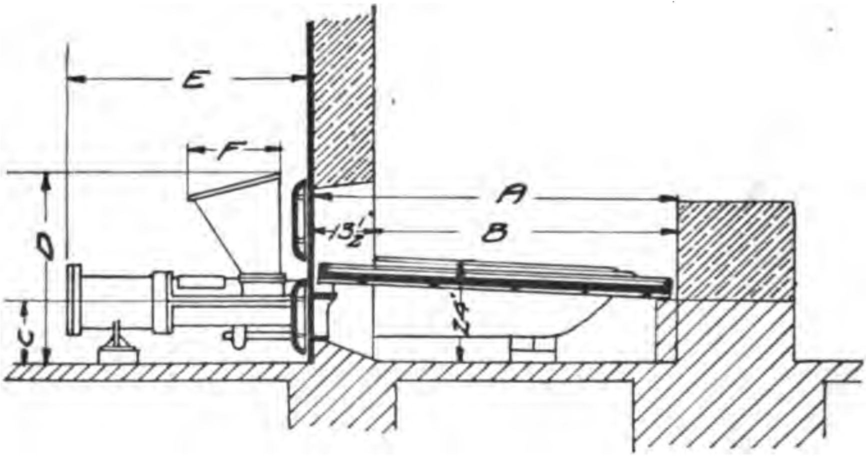

Fig 2. Longitudinal Section of Jones Stoker.

Fig. 3 shows a cross-section through the furnace with a single retort. Air from the blower is forced into the sealed ash-pit

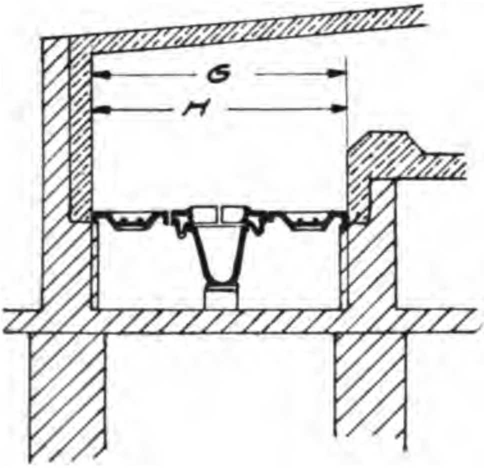

Fig. 3. Cross-Section of Jones Stoker.

through the duct, the supply being controlled by the blast gate in the line. From the ash-pit the air passes under pressure through the hollow tuyeres into the furnace. Note that air is introduced above the green fuel but below the fire, so that volatile matter driven off during the coking process is thoroughly mixed with air before passing through the incandescent fuel bed.

About 1901, Ellwood Taylor developed the first successful multiple-retort underfeed stoker. The first installation of this stoker was a three-retort, inclined-slope stoker with mechanical drive for the rams. This was installed in 1905 at the plant of the Narragansett Brewing Company, Providence, R. I. There was no secondary means of propelling the coal after it entered the furnace and the tuyeres extended throughout the length of the retort down into the dump plate. In August, 1905, two eight-retort stokers were installed at the plant of the Bay State Street Railway Company, at Quincy Point, Mass. This installation is in operation to-day and a test was run on it only last year. The results compare favorably with the more modern installations.

The multiple-retort, underfeed stoker business grew slowly. In April, 1907, one stoker was installed on trial at the plant of the New York Edison Company. The results justified the installation of 12 more stokers in August, 1907, but it was not until February, 1911, that an order was received from this same company for 56 seven-retort stokers. This sale is a milestone in the history of the underfeed stoker, because the attention of engineers all over the country was directed to the value of the multiple-retort, underfeed stoker for large central-power stations and the sale of the multiple-retort stoker increased by leaps and bounds. As the size of boilers increased the number of retorts per furnace increased until to-day there are underfeed stoker installations with stoker furnaces 18 retorts wide. Where boilers are stoked both front and back, we have installations up to 30 retorts per boiler. One of the largest underfeed stoker installations in the world to-day in number of retorts per boiler is an order which has just been placed for twelve 28-retort stokers for the Hell Gate plant of the New York Edison Company under twelve 1800-horse-power, water-tube boilers.

This stoker is made in several types adapted for various loads and various fuels, but, in general, the following description will cover this equipment.

Coal is fed from a hopper by mechanically driven rams into a series of sloping passages called retorts. Air is supplied to the fuel bed by some form of forced draft, through a series of cast-iron boxes called tuyere boxes, which are covered by perforated cast-iron blocks called tuyeres. The progress of the fuel bed toward the dump is assisted by secondary rams and by the force of gravity, owing to the slope of the retorts. Beyond the retorts is an overfeed section called an extension grate. From the extension grate the coal passes on to the dump plate. If the rotary ash discharge is used, the dump plate is omitted. When the dump plate is used the hot refuse accumulates on it to be dumped every three to six hours depending on the rate of working.

The rams are driven in groups feeding four retorts or less, by sprockets and worm-gearing from a driving-shaft below the floor. Shearing pins protect the mechanism in case a lump of foreign matter blocks a feed ram.

An interesting boiler test showing the high capacities and efficiencies attainable is one conducted by Dr. D. S. Jacobus at the plant of the Detroit Edison Company on a special double-end Stirling boiler with Taylor stokers*

A short summary of one of the tests in the series is as follows. The coal used was "Red Jacket."

ANALYSIS

Moisture	1.98	Ash	7.17
Volatile matter	32.20	Sulphur	0.99
Fixed carbon	58.65	B.t.u. as fired	13,749

DURATION OF TEST, 24 HOURS

Grate area of stoker, square feet	405
Coal burned per square foot of grate, pounds	28
Per cent. CO_2 in flue-gas	14
Average temperature of flue-gas, degrees F	575
Heating surface of boiler, square feet	23,654
Coal burned per horse-power as fired, pounds	11,310
Evaporation per pound from and at 212 degrees F	10.91
Boiler efficiency	77.07

The results of this test were very fully discussed before this Society at the time of the presentation of a paper on chain-grates given by one of our members, Mr. John A. Hunter, Steam Engineer of the American Sheet & Tin Plate Company, and recorded in the PROCEEDINGS, vol. 31, 1915, pages 1–55.

The success of the first multiple-retort stoker naturally attracted competition so that to-day there are several other large companies manufacturing this type of stoking equipment. We will endeavor to take up the better known types in the order in which they appeared on the market.

The next stoker to appear on the market was the Riley stoker, which made use of the overfeed section and continuous dump.

Mr. Sanford Riley was chief engineer of the American Ship Windlass Company in the early days of the Taylor stoker, but about 1913 he severed his connection with this company and began the manufacture of his own stoker. He was living in Providence, R. I., at this time and through his friendship with the officers of the Narragansett Electric Light Company he was able to make use of one of their boilers and install the first machine as an experiment. This early installation did not have the continuous automatic dump plate that is characteristic of this stoker to-day. See Fig. 4.

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*Trans. A. S. M. E. 1911. v. 33, p. 565

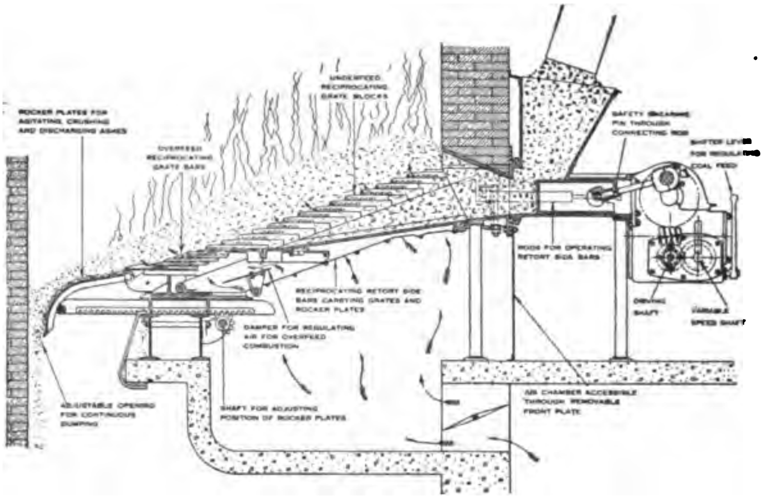
ROCKER PLATES FOR AGITATING, CRUSHING AND DISCHARGING ASHES
OVERFEED RECIPROCATING GRATE BARS
UNDERFEED RECIPROCATING GRATE BLOCKS
RECIPROCATING RETORT SIDE BARS CARRYING GRATES AND ROCKER PLATES
DAMPER FOR REGULATING AIR FOR OVERFEED COMBUSTION
ADJUSTABLE OPENING FOR CONTINUOUS DUMPING
SHAFT FOR ADJUSTING POSITION OF ROCKER PLATES
SAFETY SHEARING PIN THROUGH CONNECTING ROD
SHIFTER LEVER FOR REGULATING COAL FEED
RODS FOR OPERATING RETORT SIDE BARS
DRIVING SHAFT
VARIABLE SPEED SHAFT
AIR CHAMBER ACCESSIBLE THROUGH REMOVABLE FRONT PLATE

Fig. 4. Riley Stoker.

Other small installations followed this in the course of events. Among some of the early installations were one at the Weehawken plant of the New York Central Railroad and another at the Yonkers plant of the same company. One six-retort stoker was installed at the plant of the Glenlyon Dye Works, Phillipsdale, R. I., the early part of 1915, when the New York Central Railroad placed an order for 12 eight-retort stokers for its plant at Port Morris, N. Y. From that time the business grew steadily, until to-day, this is one of the standard makes. In 1915, the largest stoker installation in the world was of this type, 16 retorts wide, at the Essex plant of the Public Service Corporation of New Jersey. There are now being installed at the Burlington, N. J., plant of the Public Service Corporation two stokers 18 retorts wide. We understand that this is the greatest number of retorts installed as a unit under one boiler. The largest stoker in this country in number of retorts per boiler is an installation of this type under ten 1140-horse-power boilers, with 30 retorts per boiler in the central power station of the General Electric Company, at Buffalo, N. Y.

At this point a short description of this stoker is in order.

Coal is placed in a hopper which extends completely across the front of the furnace. At uniformly spaced intervals underneath the hoppers are cylinders with ram plungers operating in a horizontal direction. The distinguishing features of this stoker are the moving tuyeres and the continuous automatic ash discharge. The motion of these tuyeres is accomplished by the reciprocation of the retort sides, so that we have, in effect, a split tuyere, the halves of which move slowly back and forth against each other. The object of this arrangement, of course, is to procure adequate agitation of the fuel bed above the retorts.

Beyond the end of the underfeed retorts, the overfeed grates extend across the entire width of the stoker. This arrangement permits all the partially burned coke—from which the volatile matter has already been distilled—to come into intimate contact with air at a lower pressure than that in the underfeed section. A lower pressure here prevents excess air blowing through the lighter and more porous fuel bed. The overfeed air pressure is at all times under control of the operator.

The reciprocating motion of the alternate retort sides and the overfeed grates at the ends of the retorts produces a continuous and automatic movement along the slope to the rocker plates. These plates have a very effective rocking motion, as they are supported at their upper ends by trunnions traveling in a horizontal path, and at the lower ends by rollers on the adjustable supporting racks shown in the accompanying illustration. The result is a combination of horizontal and vertical motion that agitates, crushes and ejects the ash. The dumping capacity of the stoker is regulated by the amount of travel given to the retort sides, and by the opening lift between the rocker plates and the bridge wall. The size of this opening is adjustable.

A recent feature is a two-speed gear box connected with the driving mechanism permitting a variation in speed of the feeding mechanism while running the stoker engine and motor at its most efficient speed.

At the time that this stoker was being tried out on its first installation in 1913 the first single-retort, underfeed stoker with air-cooled, agitated grate-bars was introduced into this country from England, where it had been in existence for a number of years. Owing to the patent situation it did not make its appearance here until this time. We refer to the type "E" stoker.

The type "E" stoker is the development of a fuel-feeding mechanism patented by Wilford R. Wood, of the Under-Feed Stoker Company, Ltd., England. The first important installations were made abroad about 1900 and shortly thereafter.

The first installation of type "E" stokers in this country was at the plant of Kirkman and Sons, Brooklyn, N. Y. These stokers are still in existence and operating satisfactorily although they were installed over eight years ago. A report on the first test conducted at this plant in October, 1913, follows. The type "E" stoker is illustrated in Fig. 5 and 6.

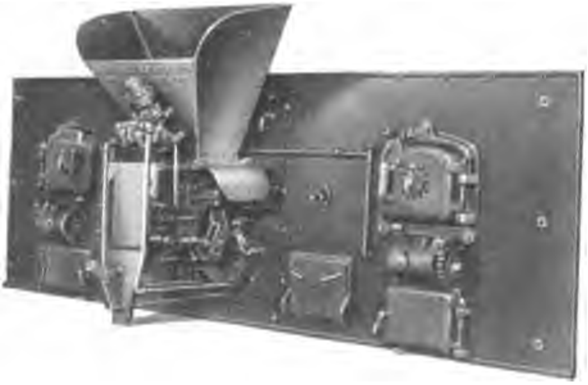

Fig. 5. Front View of Type "E" Stoker.

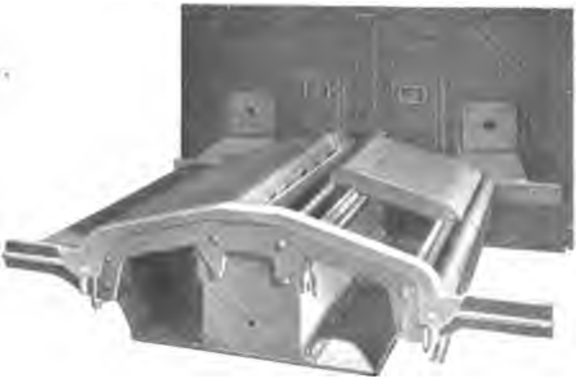

Fig. 6. Furnace Interior of Type "E" Stoker.

Previous to this date this machine had been installed in large numbers throughout the British Isles and the continent of Europe by the company which is now and has been for some time acting as representative of this stoker abroad. Many of their earlier installations made before the stoker was brought to this country are still in operation. An early test conducted previous to 1918, in Wales, by the consulting engineer of the colliery company in whose plant the machines were installed, is summarized below. The coal burned was Welsh (Glam) known as "Ferndale small."

ANALYSIS

Per cent. moisture	1.28
Per cent. volatile matter	12.75
Per cent. ash	17.0

DURATION OF TEST, EIGHT HOURS

Heating surface of boiler	6209	sq. feet
Evaporation per hour from and at 212 degrees F	37,530	lbs.
Grate area of stoker	120	sq. feet
Coal burned per square foot of grate	30.6	lbs.
Per cent. of CO_2 in flue-gas	13.2	
Temperature of flue-gas	477	degs. F.
Coal burned per hour	3678	lbs.
Evaporation per pound of coal from and at 212 degrees F.	10.2	lbs.
Calorific value of fuel per pound	12,170	B.t.u.
Boiler efficiency	80.9	per cent.

Briefly, the principle of operation of this stoker is as follows:

The coal is fed by coal conveying machinery or hand labor into the stoker hopper, and carried under the fire by means of the reciprocating sliding bottom of the retort. The coal is delivered uniformly from front to rear by the auxiliary pushers, and as it rises in the retort is distributed to the sides of the furnace by means of the moving fire-bars. The burning fuel is constantly carried by the action of these fire-bars to the dumping trays along each side wall where the resulting ash is deposited. These trays are dumped by means of a ratchet and lever on the outside of the furnace front. The stoker automatically clears the active part of the fire of ash and clinker. As the coal rises in the retort it is flooded onto the fire-bars, which are arranged in pairs, alternately moving and fixed. The moving bars work transversely to the retort, the motion being horizontal, and about one-half inch to one inch in extent.

The general design of this stoker has remained unchanged although there have been a few minor changes in the course of its development.

About 1915, the Westinghouse Machine Company realized the value of the underfeed stoker and began to manufacture one. This stoker is of the multiple-retort, downwardly inclined type, but the noteworthy features are the tuyeres and the admission of air to the dump plate, so that all combustible of the ash may be burned out before dumping.

The first installation of this underfeed stoker was in the Seventy-fourth Street station of the Interborough Rapid Transit Company, in 1915. It consisted of one seven-retort stoker placed under a 525-horse-power Babcock & Wilcox boiler. This stoker is still in operation and giving satisfaction.

The latest and largest installation of single stokers of this type is that of seven 17-retort stokers placed under 2080-horse-power Babcock & Wilcox boilers at the Colfax, Pa., station of the Cheswick Power Company. These latest stokers form one of the largest installations of their class of single-ended stokers yet installed in this country.

The Westinghouse underfeed stoker consists of a hopper extending the full width of the stoker across the boiler front with a number of downwardly inclined rams operated from a crankshaft as a fuel feeding mechanism. The underfeed section of this stoker is stationary, and downwardly inclined adjustable secondary rams assist the progress of the fuel towards the dump plate after it has entered the furnace. There is a reciprocating adjustable overfeed section between the retorts and the live dumping grates. The admission of air to this dumping plate with a separate air-controlling mechanism is a distinguishing feature of this stoker, as has been previously mentioned. This type of stoker is shown in Fig. 7.

The elaborate provision for control of the air in different zones and the special tuyeres with their graduated openings, from small openings in front of the tuyere where the fuel bed is thinnest

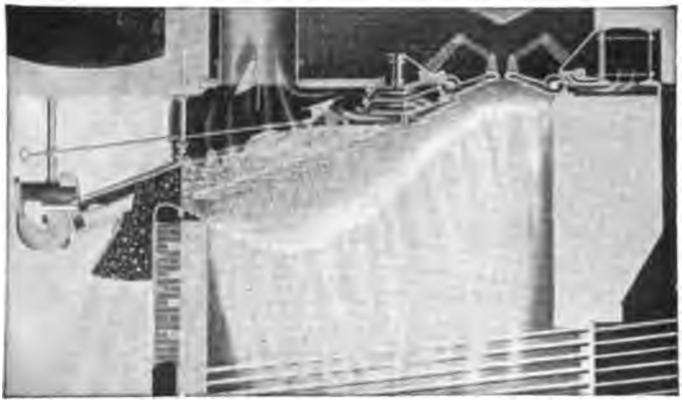

Fig. 7. Westinghouse Stoker.

to large ones at the sides where the fuel bed is thickest, are two features of considerable merit in this type of equipment.

About 1916, Mr. Joseph H. Roach, of Philadelphia, brought out a single-retort underfeed stoker with a somewhat different system of air control from that used by other single-retort underfeeds.

The first two installations were local ones, namely the Miller Lock Company, Frankford, Philadelphia, and Alfred Wolstenholm & Son, Philadelphia. Since the early installations a steady growth in the sale of this stoker has been noteworthy and members of this Society are no doubt familiar with this equipment from installations which have been added from time to time in this district.

This machine is of that type underfeed which feeds the green coal directly down the center of the furnace from which point it rises beneath the burning fuel and is distributed at right angles to the retort. It deposits its ash along the side walls and has an ash-pit on either side of the furnace.

The advantages claimed for this machine are, simplicity, accessibility, low maintenance cost, and the ability to reach high efficiency due to its system of air controls in addition to the usual advantages of all underfeeds.

The coal is forced into the retort by means of a steam cylinder acting in a direct line with and on the coal plunger. The distribution of fuel in the retort is similar to a well-known arrangement, originally perfected many years ago.

Fig. 8 shows a longitudinal section through the middle of the retort, illustrating the arrangement of the feed rod and the auxiliary pushers. The arrangement of the first pusher located under the boiler front, is novel and original with this machine.

In Fig. 9 there may be noted the manner of admitting the forced draft to this machine, through a branch taken from the main air ducts; the opening through this branch being controlled by a butterfly-valve located immediately beneath the steam cylinder. The air passes from this point into a much larger chamber located beneath the stoker and side bearer bars shown in Fig. 9 in cross-section.

All of the air required for the high-pressure zone—that zone located immediately above the retort—passes first through a hollow bearer bar, which at the same time supports the lower end of the grate-bars and thence passes through the hollow section of these bars, toward the center of the furnace and out into the green fuel in the retort. In its passage through the bars, the air becomes pre-heated and this factor greatly hastens and assists combustion. It will be recognized that the air required below this point, is merely for the purpose of supporting combustion of a coked fuel and will therefore not require air at the same pressure as is necessary at the retort. The air in this zone is therefore reduced in pressure by means of an air-control valve, shown on both Fig. 8 and Fig. 9, and which is located directly beneath the retort and which discharges its air into a large chamber extending from wall to wall between the bearer bars, which support the lower ends of the grates. By this means an even static pressure is maintained under the entire grate surface and air from this chamber passes upward between the grate-bars into the burning coke, cooling the bars on the outside in its passage.

The opening into this chamber is subject to regulation from the outside of the furnace and the proportion of this air taken to the various zones can be regulated at will. As coals and furnace sizes vary, the manufacturer emphasizes this point and also

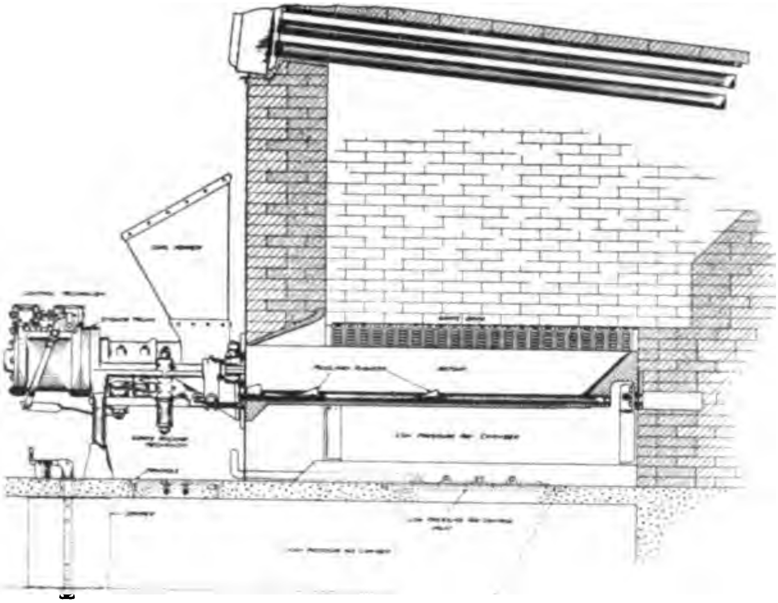

Fig. 8. Roach Stoker.

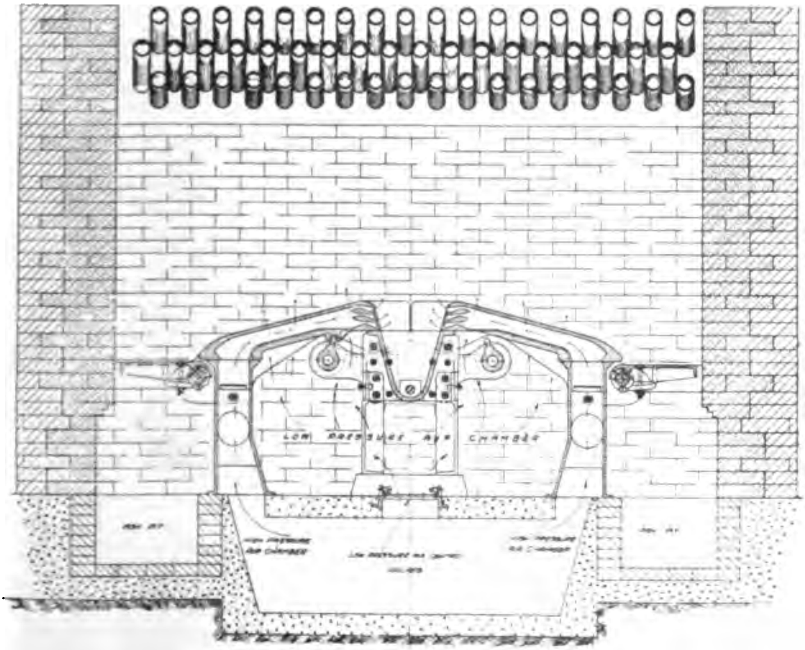

Fig. 9. Roach Stoker.

particularly lays stress upon the fact that all of the air used for supporting combustion, is first used for cooling the grate-bars.

After the development of the standard Jones stoker, the Under-Feed Stoker Company of America continued to refine and improve its underfeed machine from time to time. This company was the first to use the power dump on end-dump stokers. One of the old types using this power dump can be seen at the Thirteenth Street plant of the Duquesne Light Company of this city.

After years of experiment and study of the success of other types of underfeed equipment the latest type of underfeed stoking equipment in the field to-day was evolved. As the Jones was first in the field of underfeed stoking equipment, so to-day the latest type on the market is a product of this same company after an experience of over thirty years. The design of the present stoker is simplicity itself and the writer would like to call attention to the fact that only one moving part per retort is within the firing chamber. See Fig. 10.

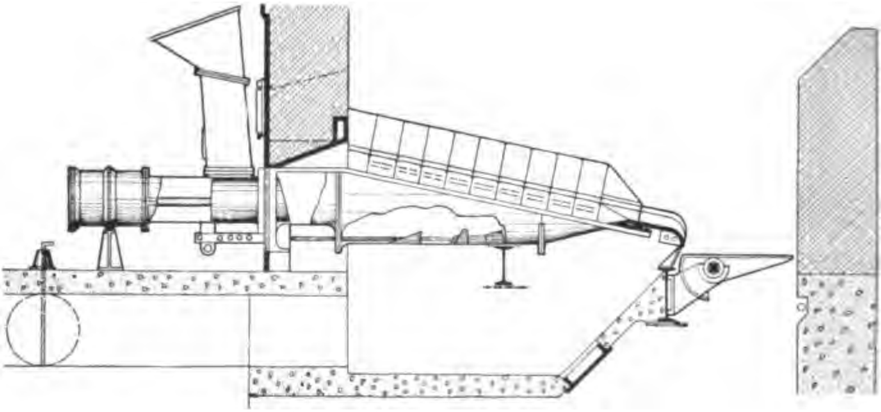

Fig 10. Longitudinal Section of Jones "AC" Stoker.

The steam ram has been retained as a drive for the ram and pusher rods as by this means an individual control of retorts is obtained. The importance of an individual control of retorts can not be overestimated.

In the effort to make simplicity the keynote of this stoker a counterbalanced, hand-operated dump plate is used. A new feature in stoker construction is the addition of side-wall tuyeres rising one foot higher than the center retort tuyeres. This is an anti-clinkering device for the protection of the furnace side walls.

The bottom of the retort is made perfectly horizontal and the slope of the tuyeres is set at an angle of 11 degrees, which is considered to be too small a slope for gravity to have any particular effect in assisting the progress of the fuel through the retorts toward the dump plate. This absence of slope is conducive to the prevention of avalanching of the fuel down onto the dump plate, thus helping to keep down the percentage of combustible in the ash. See Fig. 11.

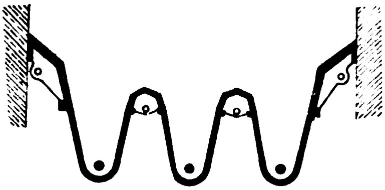

Fig. 11. Cross-Section of Jones "AC" Stoker.

By not having any particular slope to the retort, a considerable amount of head-room has been gained in the distance from the top of the fuel bed to the boiler tubes, and, in cases where old installations of boilers are to be stoked, this point has proved to be an important factor in permitting this type of underfeed stoker to be installed where lack of sufficient head-room has made it inadvisable to put in other multiple retort underfeed types.

After completing the design of this new type of stoker equipment, a two-year period of service in the field, for determining the value of this stoker, was decided upon. Trial installations were made on 300-horse-power Stirling boilers at the plant of the Federal Products Company, the plant of the Ault & Wiborg Company, and the plant of the American Diamalt Company, all in Cincinnati, and several others which we will not take the time to mention at present. The years 1917 and 1918 were included in this test period and this stoker was finally released for general sale in 1919. From that date rapid strides have been made in the sale and installation of this particular type until, to-day, it ranks among one of the better known multiple-retort, underfeed stokers.

A test recently conducted at the plant of the Monongahela Valley Traction Company, at Parkersburg, W. Va., showing the high efficiencies and capacities attainable with this latest type stoker, follows.

RESULTS OF BOILER TEST

Conducted by R. L. Beers. Observed by O. B. Summers. May 15, 1920. Babcock & Wilcox horizontal wrought-iron boilers, 441 rated horsepower. Type "AC" five-retort stokers.

CONDITIONS

Duration, hours	8.33
Steam pressure, pounds gage	200.9
Superheat, degrees F	152.4
Temperature of feed-water, degrees F	185
Temperature of escaping gases (breeching)	503
Pressure in air chamber, inches	4.43
Draft in furnace, inches	0.04
Draft between damper and boiler, inches	0.74

Flue-gas analysis

Carbon dioxid (CO_2) per cent	11.33

COAL

Total weight as fired, pounds	29,840
Total weight water fed to boiler, pounds	275,485
Factor of evaporation	1.1631
Total equivalent evaporation from and at 212 degrees F., pounds	320,416

Analysis

Fixed carbon, per cent	51.05
Volatile matter, per cent	38.98
Ash, per cent	9.31
Moisture, per cent	0.66
Sulphur (sep. det.) per cent	1.24
B.t.u. per pound dry	13,796
B.t.u. per pound as fired	13,705

SUMMARY

Coal burned per hour as fired, pounds	3582.2
Coal burned per hour per retort, pounds	716.4
Water evaporated from and at 212 degrees F. per hour, pounds	38,450.1
Boiler horse-power developed (average)	1114.5
Per cent. of rated capacity developed	252.7
Water evaporated actual per pound coal as fired, pounds	9.23
Water evaporated from and at 212 degrees F. per pound of coal as fired, pounds	10.74
Water evaporated from and at 212 degrees per pound of coal dry, pounds	10.81
Efficiency of boiler, furnace and grate, per cent	76.05

APPLICATION

It is the object of this portion of the paper to endeavor to show that the underfeed type of stoker is able to burn almost any kind of coal produced in this country. It is true that other types of stoking equipment are able to burn certain kinds more efficiently than the underfeed, but where other factors are to be considered, such as load conditions, draft conditions, etc., it may be advisable to use the underfeed type of stoker in any case. Throughout the United States, the combustion characteristics of the various coals vary considerably. In the Eastern portion are the anthracites and such coals as New River, Pocahontas and Clearfield from West Virginia and Maryland working gradually into the bituminous field. In the Middle West are Indiana, Illinois, and Kansas coals, which with their free burning action differ greatly from coals in other sections. In Colorado we have Denver lignites with a high percentage of moisture and still different lignites in both Texas and North Dakota.

The larger sizes of anthracite are almost universally used for domestic purposes, while the smaller sizes are used for steam generation. On account of a high percentage of fixed carbon in anthracite and a small amount of volatile matter, this coal is very difficult to ignite and requires very careful firing. However, if a small amount of bituminous coal with its high percentage of volatile matter be added to the anthracite, fair results can be obtained and the cost of steam generation can be considerably lowered.

There are hundreds of plants throughout the East operating with underfeed stokers burning mixtures of anthracite and bituminous coal. One or two examples taken at random from plants operating in the East will illustrate this condition as the writer has found it.

The power-plant of the Ingersoll-Rand Company is burning a mixture of one-third anthracite and two-thirds bituminous coal with Jones underfeed stokers on Stirling boilers. At times they reverse this percentage.

The Central Islip Hospital, on Long Island, is burning mixtures of 50 per cent. anthracite and 50 per cent. bituminous coal on 600-horse-power water-tube boilers with this stoker. They have developed as high as 1000 horse-power with this mixture.

The Lewiston Bleachery & Dye Works, at Lewiston, Me., has a Jones "AC" stoker installation burning mixtures of 25 to 33 per cent. of hard coal screenings, the balance being Pocahontas coal. They have obtained an average efficiency of 74 per cent., the boilers being run anywhere from rating to 250 per cent. of rating, the loads being quite variable at the bleachery.

You can go any day to the Amoskeag mills and see one row of 52 boilers, which is one of the longest boiler houses in existence, and see the standard type of Jones stokers burning anthracite with 25 per cent. bituminous coal, though anthracite is frequently burned alone on these stokers.

It is almost useless to discuss the field of underfeed stokers in connection with bituminous coal. The amount of high volatile matter in this fuel makes it ideal for use in connection with this type of stoker and this fact is so well known to engineers at the present time that we will not go into the matter at present.

In connection with Middle Western fuels, during the past few years, the chain-grate type of stoker has enjoyed great popularity; however, the demand for flexibility in equipment and the possibilities of higher boiler ratings have created a considerable market for the underfeed stoker in this territory, with the result that a reasonable doubt has arisen as to the advisability of installing chain-grates foı Middle Western fuels. In a great many plants it is now the practice to utilize what chain-grate equipment they already have and operate it at its most efficient rating, in the meantime equipping other boilers with high-duty underfeed stokers. These boilers which are stoked with the underfeed mechanism are floated on the line and take care of all peak-loads and demands for unusual capacities, allowing the chain-grates to pursue their own gait undisturbed. We submit a brief record of a test of the performance of an underfeed stoker applied to a 558-horse-power boiler when burning Illinois Carterville coal:

Per cent. of boiler rating during test	163	182	212	328
Duration of test, hours	12	12	12	2
Temperature of flue-gases, degrees F.	512	489	562	633
Pounds of dry coal per square foot of grate surface per hour	27.7	34.9	37.2	62.3
Carbon dioxid, per cent	13.6	13.4	13	15.1
Per cent. efficiency of boiler, furnace and grate, based on dry coal	77.7	76.1	76.4	
Calorific value of coal as fired B t.u. per pound	11,877	10,226	11,232	11,378

Average proximate coal analysis	
Per cent. moisture	10.3
Per cent. volatile matter	28.9
Per cent. fixed carbon	41.8
Per cent. ash	18.9
B t.u. as fired	10,226
B.t.u. dry	11,401

There are a great many chain-grate stokers burning lignite and, in a general way, they are all satisfactory. We understand that a great deal of experimentation has been made by the various underfeed stoker companies in order to adapt this type of stoker to handle this coal and a considerable degree of success has been attained.

There seems to be some difference of opinion as to the method of handling the fuel bed with this type of coal. Mr. Joseph G. Worker, stoker engineer for the Westinghouse Electric & Manufacturing Company, states as follows:*

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*Combustion Characteristics of Coals and Selection of Suitable Stoker Equipment. (In Electric Journal, 1918. v. 15. pp. 120–123.)

"A very heavy fuel bed must be carried, which is, of course, an easy trick for an underfeed stoker and the air supply adjusted. It was found that this coal was extremely easy to handle and any clinkers that formed could be easily removed at the rear of the stoker."

On the other hand, the writer is in receipt of a letter from Mr. A. H. Blackburn, chief engineer of Under-Feed Stoker Company of America, stating that it is the practice of this company to carry a very light fuel bed. This company has burned as much as 1500 pounds of lignite per retort per hour, on its standard type stoker, with very good results.

We submit two tests showing the results obtained with the two different methods of burning this fuel. The first test is one reported by Mr. Worker in his paper on North Dakota Lignite Coal, carrying a thick fuel bed with a Westinghouse underfeed stoker.

Pluma Station, Consolidated Power and Light Company, Deadwood, S. D. Boilers No. 4 and No. 5.

Test conducted by operating department, January 8, 1916. B. & W. boilers each fired by two Jones stokers

Heating surface	3500 sq. feet
Superheating surface	417 sq. feet
Duration of test	8 hours
Intervals of observation	15 min.
Kind and size of coal	Monarch, Wyo., screenings—2½ in.

Weather conditions—cloudy—still.

Average temperatures and pressures

Steam pressure gage	164.00
Steam pressure absolute	176.36
Barometer	25.20
Temperature of feed-water	197.00
Temperature of steam	439.50
Temperature of flue-gas	483.00
Temperature of air in boiler room	66.00
Temperature of air outside	40.00
Superheat	68.00
Air pressure at fan discharge, inches of water	3.24
Air pressure under grate, inches of water	1.49
Draft above fire	0.011

Total quantities

Weight of coal as fired	37,399
Per cent. of moisture in coal, by analysis	21.08
Total weight of dry coal	29,500
Total weight of ash and refuse	1,515
Total weight of water fed to boilers	252,600
Total weight of water corrected for difference in levels at beginning and end of test	252,000
Total equivalent evaporation from and at 212 degrees F	278,200

Capacity

Evaporation per hour from and at 212 degrees F	34,776
Boiler horse-power developed	1,008
Boiler horse-power rated	700
Per cent. of rated capacity developed	144
Average load on turbine served, kilowatts	1,200

Economic results

Water fed per pound of coal fired	6.74
Equivalent evaporation from and at 212 degrees F. per pound of coal fired	7.44
Equivalent evaporation from and at 212 degrees F. per pound of coal, dry	9.43

Efficiency

Calorific value of one pound of dry coal, B.t.u	12,224
Efficiency of boiler, furnace, and grate, per cent	74.9

Proximate analysis of coal

	As fired	Dry
Per cent. moisture	21.08	
Per cent. volatile matter	35.10	44.50
Per cent. fixed carbon	38.80	49.20
Per cent. sulphur	0.53	0.66
Per cent. ash	5.04	6.39
B.t.u. as fired	9640	

W. W. CASSIDY, *Supt.*

A second test is one submitted by Mr. Blackburn, showing the results obtained with the Jones standard type stoker carrying a thin fuel bed on this same North Dakota lignite.

RESULTS OF AN UNDERFEED STOKER TEST APPLIED TO A 600-HORSE-POWER BOILER WHEN BURNING NORTH DAKOTA LIGNITE

Per cent. of boiler rating during test	123	139
Duration of test, hours	6	7
Temperature of flue-gases, degrees F.	467	467
Pounds of dry coal per square foot of grate surface per hour	32.4	31.4
Carbon dioxid, per cent.	13.2	12.6
Per cent. efficiency of boiler, furnace, and grate, based on dry coal	56.2	64.6

Proximate analysis of coal

Per cent. fixed carbon	30.0	30 3
Per cent. volatile matter	29.7	28.3
Per cent. moisture	34.4	33.5
Per cent. ash	5.9	7.9
B.t.u. as fired	7029	7120

COKE BREEZE

Up to recent date there seems to have been a general opinion among engineers that coke breeze should be burned on a specially designed stoker of the chain-grate type. There is some foundation for this theory in view of the fact that underfeed stokers are primarily a modified type of gas-producer, which burn gas that they produce, and coke breeze is very low in volatile matter. However, there are a number of objections to the chain-grate type of stoker for burning coke breeze.

1. The stoker will not handle bituminous coal satisfactorily.
2. A large grate area is needed to get rating from the boiler.
3. The fire has to be closely watched to maintain proper depth of feed, travel of fuel bed, and varying pressures in the different zones.
4. Long, low combustion arches are required, which are expensive to maintain, and cut off radiant heat.
5. Stokers cannot meet varying load conditions, or handle heavy overload.
6. Abrasive nature of the breeze causes rapid wear on the many moving parts required, thus causing high maintenance expense.
7. When installed in connection with boilers of the bent tube type, the blow-pipe action caused by the low arch is harmful.
8. While evenness of fuel bed can be maintained, uniformity in quality of the fuel cannot, and the results are disastrous.

9. Local conditions sometimes make the installation of this type of stoker impracticable.

1. Referring to our first criticism that this type of stoker will not burn bituminous coal satisfactorily, we refer to an article* by Joseph G. Worker, stoker engineer for the Westinghouse Electric & Manufacturing Company.

Mr. Worker states as follows:

> "There are many plants in the Pittsburgh district where chain-grate stokers are used. While it cannot be said that this stoker is wholly unsatisfactory for these fuels on account of their coking qualities and the characteristic caking effect, the principle of the chain-grate stoker is fundamentally wrong for such coals. The manner in which they act on a chain-grate stoker was quite apparent in a test recently conducted on a chain-grate stoker having a front coking plate. As the coal ignited, it was pushed off this coking plate by means of plungers and it passed onto the chain part of the stoker in large lumps, resembling blocks. On this particular stoker, forced draft was used. By viewing the furnace fire, it could be seen that the air was going up between these blocks of coke and not through them. In other words, it seemed that if one could get into the furnace and paddle down the fuel bed, covering up these holes, proper results could be obtained. In general, this is the action of this coal on any type of chain-grate stoker."

2. In support of our criticism that a large grate area is needed to get rating from the boiler, we believe that this is a well known fact and need not be discussed at the present time. However, we would like to call attention to the fact that, in the case of the underfeed stoker, grate area is of very little importance. Among engineers, when making up tabulated comparisons of competitive types of underfeed stokers, there seems to be an opinion that the item of grate area is a factor of considerable importance in determining the selection of stoking apparatus. On this point we quote briefly from an article by Mr. F. H. Daniels,† chief engineer of the Sanford Riley Stoker Company.

> "In the case of the underfeed stoker grate area is not of much importance. The capacity that can be obtained from the stoker is dependent only to a small degree on the grate area.

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*Combustion Characteristics of Coals and Selection of Suitable Stoker Equipment. (In Electric Journal, 1918. v. 15, pp. 120–123.)

†Grate Area and the Underfeed Stoker. (In Power, v. 47, pp. 373–374.)

The amount of coal that can be fed by the stoker is limited only by the mechanical strength of the stoker parts. To burn this coal, it is only necessary to provide a sufficient blast pressure, under the grates, sufficient openings through the grates, and means for keeping the fuel bed open so that the air may find a passage through it.

As an index of the value of any underfeed stoker, the relation between distillation, or retort volume and total volume of coal is of most importance. By distillation, or retort volume is meant the volume of coal in the retort between the tips of the tuyeres, or grates, including the throat under the front wall in front of the feeding plunger. By total volume of coal, is meant the retort volume plus a one foot thickness of fuel over the entire surface of the stoker. This one foot will allow for the usual thickness of eighteen to twenty-four inches in the thickest part of the fire down to six or eight inches on the overfeed section and the dump plates."

3. Our criticism that the fire has to be closely watched to maintain proper depth of feed, travel of fuel bed, and varying pressures in the different zones, seems to us to be self evident and needs no discussion here.

4. The fact that long, low combustion arches are required, which are expensive to maintain, seems to the writer not to be so important as the fact that these arches cut off the radiant heat to a great extent. The enormous amount of work done by radiant heat in steam generation was very forcibly brought to the attention of this Society in a paper by Mr. John E. Bell on the theory of heat transmission and absorption.* Possibly 85 per cent. of the work done in generating steam with coal burning equipment is done by the radiant heat.

5. It is a well known fact that it is a rather difficult matter to speed up a chain-grate stoker to meet varying load conditions, or to handle heavy overloads. The response to peak-loads is very slow compared to what the modern types of high-duty underfeed stokers are capable of doing.

6. High maintenance of this type of stoker is caused by the abrasive nature of the breeze, which causes rapid wear on the many moving parts. The writer, personally, believes that an underfeed stoker with the smallest number of moving parts possible is the logical machine for burning coke breeze mixtures.

*PROCEEDINGS, v. 32, p. 797.

7. The long, low ignition arch, together with the intense combustion caused by the use of forced draft, results in a blow-pipe effect, concentrating the flame on the lower portion of the boiler tubes, where a vertical or bent-tube boiler is used. In the case of horizontal water-tube boilers, this criticism has very little weight. We are under the impression, however, that the bent-tube type of boiler is more generally in use in steel mills, and it is the steel mill that offers the greatest market for coke breeze burning equipment. The blow-pipe action on the portion of the tube leading into the bottom drum of the vertical or bent-tube boiler is directed against the part of the tube that is least prepared to stand it. It is always the bottom part of this tube that is least effectively cleaned where the cleaning is not done thoroughly, a condition which the writer has personally observed to be the case at many plants. Furthermore, he has noticed that when scale is cleaned from the upper drum, it sometimes happens that small pieces drop down through these tubes and lodge in the bottom curve of the tube, just opposite where the arch over the chain-grate type of stoker is concentrating the heat with the previously mentioned blow-pipe effect. The results can well be imagined.

8. The writer has talked with engineers of steel mills in this district, who report that while the chain-grate type of stoker is able to maintain a fuel bed of uniform thickness, there is no such thing as uniformity of quality with coke breeze. The result is that, no matter how the forced draft is divided into zones under the chain grate, there will appear black spots and craters in the fire, and the edge of the fuel bed just before it is dumped has a great many promontories and indentations, showing that, owing to this lack of uniformity of quality, the fire has burned out more quickly in some spots than in others, thus allowing an inrush of cold air through the dead spots in the fuel bed, producing stratification of the gases with their accompanying cooling effect on the setting, and general loss of efficiency.

9. Local conditions, such as load conditions, insufficient supply of breeze, etc., sometimes make the installation of this type of stoker impracticable.

There seems to be some doubt in the minds of engineers as to whether an underfeed stoker can burn pure coke breeze with good commercial success; but the writer knows, personally, of several plants with several different types of underfeed stokers where they have burned and are burning pure coke breeze with commercial efficiency. The greater number of plants, however, owing to various local conditions, are burning mixtures of coal and coke breeze. A little coal mixed in with the breeze acts as a binder on the whole mass and furnishes sufficient volatile matter to make quick and brisk ignition.

During the summer of 1919, tests were made by the Ford Motor Company to determine the feasibility of burning various mixtures of coke breeze and coal. The Semet-Solvay coke breeze burned was from the new Ford steel plant and ranged in size from dust up to ⅜ inch. A mixture of two parts coke breeze to one part coal was first used. The mixture was then changed to three parts coke breeze to one part coal and as a result of these tests Charles Koehler, chief engineer, Ford Hospital, Detroit, has burned a mixture of two parts coke breeze and one part coal very successfully and at a considerable financial saving. The coke breeze is stored in a bin separate from the coal and the charge is mixed by dropping alternate charges of coke breeze and coal into a traveling bin. The mixture then descends through a short chute into the hopper of the stoker. It is the intention of the Ford Motor Company to burn coke breeze mixtures at its new River Rouge, Detroit, steel plant, under four boilers now being equipped with these stokers.

A test on coke breeze mixtures with underfeed stokers follows:

RESULTS OF BOILER TRIAL

The following shows the results of a boiler trial made at the plant of the Michigan Limestone and Chemical Company, Rogers City, Mich., December 4, 1919. The object of the tests was to secure data on burning mixtures of one part coal and three parts coke breeze; also one part coal and two parts coke breeze.

	100 pounds coal to 325 pounds coke	100 pounds coal to 225 pounds coke
Boiler	Stirling	Stirling
Rated horse-power	294	294
Stokers	Type "AC"	Type "AC"
Number of retorts	3	3
Conditions		
Duration, hours	8.0	8.0
Steam pressure, pounds gage	148.2	149.6
Temperature of feed-water, degrees F.	179.9	168.8
Temperature of escaping gases, degrees F.	594	608
Pressure in air chamber, inches	2.8	2.7
Draft in furnace, inches	0.15	0.14
Draft between damper and boiler, inches	0.33	0.28
Flue-gas analysis		
Carbon dioxid (CO_2) per cent	12.4	12.2
Oxygen (O) per cent	7.8	7.6
Carbon monoxid (CO) per cent	0.0	0.0
Weight coal as fired, pounds	4,550	5,800
Weight coke breeze fired, pounds	14,785	13,050
Coal		
Total weight as fired, pounds	19,335	18,850
Total weight water fed to boiler, pounds	106,068	115,889
Factor of evaporation	1.079	1.090
Total equivalent evaporation from and at 212 degrees F., pounds	114,487	126,319
Analysis of mixture as fired		
Fixed carbon, per cent	59.06	56.98
Volatile matter, per cent	10.67	13.62
Ash, per cent	15.36	13.82
Moisture, per cent	14.91	15.58
Sulphur (sep. det.) per cent	1.01	1.04
B.t.u. per pound dry, per cent	11,413	11,738
B.t.u. per pound as fired, per cent	9,709	9,909

Analysis as fired

	Coal	Coke	Coal	Coke
Fixed carbon	55.80	60.06	53.15	58.68
Volatile matter	29.25	4.95	33.39	4.84
Ash	8.45	17.49	6.46	17.08
Moisture	6.50	17.50	7.00	19.40
	100.00	100.00	100.00	100.00
Sulphur	1.59	0.83	1.56	0.81
B.t.u.	12,856	8,741	12,968	8,549

Summary

Coal burned per hour as fired, pounds	2,417.0	2,356
Coal burned per hour per retort, pounds	806	785
Water evaporated from and at 212 degrees F. per hour, pounds	14,310.9	15,789.9
Boiler horse-power developed (average)	414.7	457.1
Per cent. of rated capacity developed	141.1	155.5
Water evaporated actual per pound coal as fired, pounds	5.49	6.15
Water evaporated from and at 212 degrees F. per pound of coal as fired pounds	5.92	6.70
Water evaporated from and at 212 degrees F. per pound of coal dry, pounds	6.96	7.94
Water evaporated from and at 212 degrees F. per pound of combustible	8.49	9.49
Efficiency of boiler, furnaces and grate, per cent.	59.1	65.6
Ratio of coke to total fuel, as fired	76.5	69.2

The underfeed stoker has found a new field in recent years in burning fuels that are generally unmarketable. Some of these are too high in ash to make it economical to ship them by freight and others have too high a percentage of sulphur, or other clinker forming elements, which make the task of burning this fuel one that can be solved only by those long experienced in combustion matters. There are many such fuels, such as yard sweepings, bug dust, bone coal, etc., which it is real economy to burn at the mine with an underfeed type of stoker. Very often in mining the vein of coal, a seam of bone coal has to be taken out with the good coal. After the company has gone to the expense of separating this coal on the picking tables, it is advisable to burn this coal if at all possible, and the question of efficiency can almost be disregarded, because the cost of steam generation is brought so low. It is well to bear in mind, however, that in designing an underfeed stoker installation for burning unmarketable fuels with high percentages of bone or slate, a considerable amount of over stoking has to be done. Not only does enough stoking capacity have to be added to overcome the 25 per cent., or more, incombustible material; but, also, it is necessary to over stoke further in order to heat up this dead material, so that the ignition temperature of the fuel bed will not be seriously affected. It was a surprise to the writer to observe that, with a coal containing at least 25 per cent. ash and 4 per cent. sulphur, the great question that arose was not the prevention of clinker formation (although the analysis of this coal sounds as if it were created to make a splendid clinker) but the initial ignition temperature was the great difficulty.

The dead matter in the fuel bed kept the temperature down sufficiently near the fusing point of the ash, so as to prevent the formation of large masses of clinker.

It is also a matter of interest to note that the underfeed stoker of the Jones standard type is finding particular favor in the metallurgical industry and has been successfully applied to heating furnaces of the types found in forging plants, sheet and pair furnaces, annealing furnaces in sheet steel mills, annealing furnaces in the malleable iron industry, etc.

The application of the underfeed stoker to heating furnaces overcomes the many disadvantages of hand firing, inasmuch as the stoker provides for a constant rate of combustion during the entire heating periods and provides for perfect regulation of the heat by mechanical means, thus eliminating the uncertainties created by uneven firing when these furnaces are hand fired. Furthermore, the stoker automatically provides for a perfect mixture of air with the gas in the coal to produce any desired atmosphere. When a reducing atmosphere is required, the rate of combustion is set at the commencement of the heat and the stoker automatically maintains this condition during the entire heating period. This, with many other features claimed for the underfeed stoker in its application to heating furnaces, has resulted in producing a better economy in coal consumption, with heat under perfect regulation and evenly distributed, which, in turn, means a greater output from the furnace and an improvement in the quality of the product.

In conclusion of this paper, the writer desires to make grateful acknowledgement for assistance received from the following engineers:

Mr. Nelson G. Phelps, Mr. A. H. Blackburn, Civil Engineer, and Mr. F. A. DeBoos, General Sales Manager, of the Underfeed Stoker Company of America; Mr. Joseph Breslove, Consulting Engineer; Mr. Joseph H. Roach, President, and Mr. Joseph C. Laird, Secretary, of Joseph H. Roach & Company; Mr. R. J.

Horne, Mr. G. A. Sacchi, and Mr. F. A. Smeltz, of the Westinghouse Electric and Manufacturing Company; Mr. R. C. Beadle, Mr. Charles McDonough, and Mr. J. M. Hopwood, of the Combustion Engineering Corporation; Mr. P. R. Hord, and Mr. C. R. Misner, of the American Engineering Company; Mr. C. L. Smith, and Mr. R. Sanford Riley, of the Sanford Riley Stoker Company; Mr. H. B. Meller, Chief of the Bureau of Smoke Regulation, City of Pittsburgh; Mr. E. H. McClelland, Technology Librarian of the Carnegie Library of Pittsburgh; Mr. K. F. Treschow, Secretary of the Engineers' Society of Western Pennsylvania, and others.

DISCUSSION

Mr. H. N. Scofield:* Mr. Rahm has presented the earlier development of the underfeed stoker so fairly, that I am simply going to carry on that development as we have made it, as the originators of the multiple-retort underfeed stoker.

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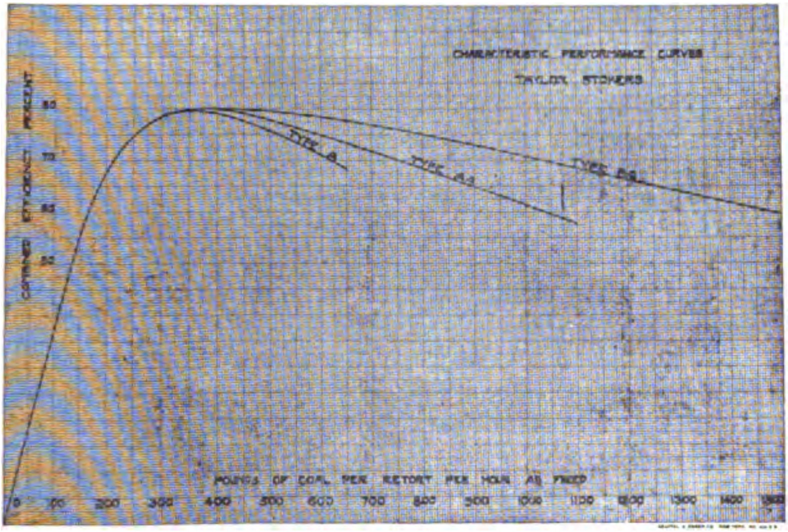

Fig. 12. Performance of Taylor Stokers.

Fig. 12 shows the combined boiler and furnace efficiencies of boilers equipped with three types of Taylor stokers. This efficiency is based on pounds of coal burned per retort per hour, and that fact will account for the difference between the form of these curves and the form of the Westinghouse curves, shown previously, based on percentage of rated boiler capacity.

The type "A" stoker is the original Taylor stoker. It was equipped with 17 tuyeres and a hand-operated dump plate. It had no extension grates. You will note that at a low fuel-burning rate, the efficiency of this stoker compares favorably with our later

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*General Sales Manager, American Engineering Co., Philadelphia.

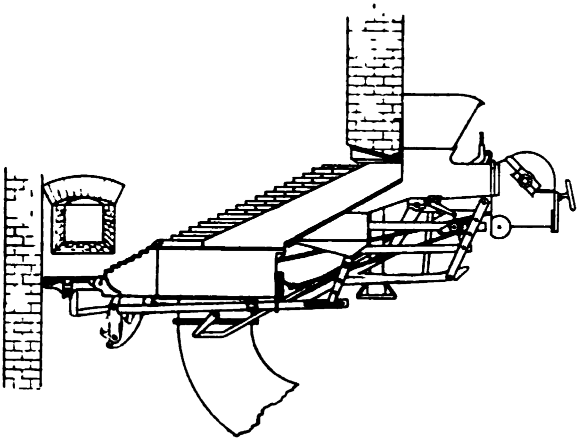

Fig. 13. Taylor Stoker with Reciprocating Grates.

stokers, known as type "AA" (Fig. 13) and type "B." However, the efficiency dropped off rapidly at higher fuel-burning rates. We found that an overfeed section to burn the fixed carbon was essential, and for that reason developed the type "AA" stoker, having an extension grate. The much higher fuel-burning rate, as well as the higher efficiency at that rate, is clearly shown by the curve marked type *AA*.

To meet demands for higher capacities, especially under narrow boilers and to burn the present low-grade fuels at high ratings. we have developed the type "B" stoker, which has three rams and 22 tuyeres per retort. This stoker will burn 1500 pounds of coal per retort per hour, and the high efficiency at all ratings is shown by the curve marked *BA*.

It should be noted that these curves are based on performance of some little time ago, and we have recently obtained higher efficiencies on both type "AA" and type "B" stokers.

The demands for high fuel-burning rates, together with the necessity of burning fuel having a low-fusing ash, have made the disposal of the ash the outstanding feature in recent underfeed stoker design. We have found that for high efficiency and capacity it is essential to maintain a sealed furnace, and this is practical only by two methods of construction.

The first of these is with a dump plate. We originally operated this by hand, but the desirability of reducing manual labor to a minimum in the boiler room so as to attract a higher grade of man for stoker operation, as well as the necessity of handling coals with low-fusing ash tending to form clinkers, induced us to develop the steam operated dump plate.

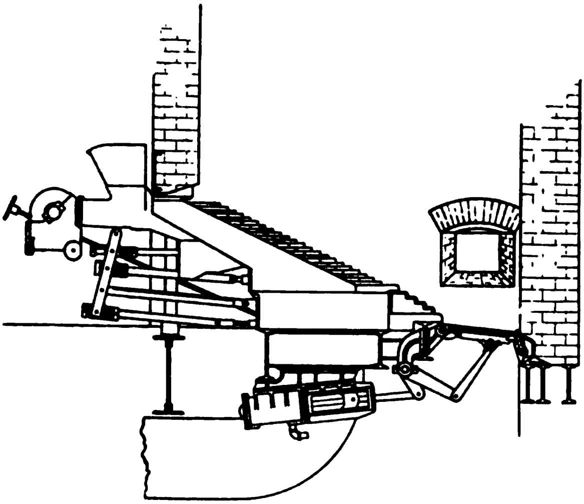

Fig. 14. Taylor Stoker with Steam Operated Dump Plate.

This is shown in Fig. 14. The plate is dropped by gravity and raised by steam power merely by manipulating two levers. It is so constructed that it can be raised 10 inches above the horizontal position to clear the bridge wall of any adhering ash. A typical installation of this type, is the new Acme power plant at Toledo, where we have four 1250-horse-power and four 1350-horse-power boilers equipped with these stokers.

The one other practical method of removing the ash from an underfeed stoker, is by the rotary clinker grinder. This was developed by us originally for the Detroit Edison Company for use under the 2365-horse-power boilers, installed at its Delray plant.

Fig. 15 shows the stokers as finally installed with an additional grate above the clinker grinder. This type of installation is being increasingly used by the larger central stations.

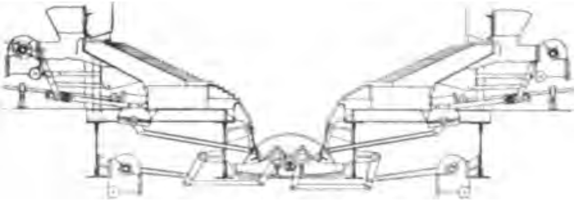

Fig. 15. Taylor Stoker.

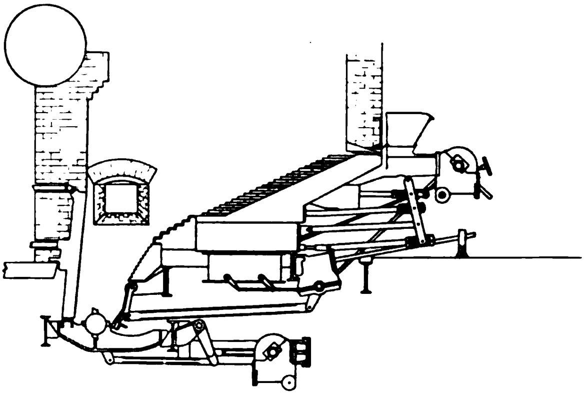

Fig. 16. Taylor Stoker with Clinker Grinder.

To meet the requirements of a single set boiler, we have developed the grinder shown in Fig. 16. This was originally installed at the Ford plant in Detroit, and numerous other installations have been made.

The Chester plant of the Beacon Light Company, controlled by the Philadelphia Electric Company, has our type "AA" stoker with the grinder in service. At its new Delaware plant, the Philadelphia Electric Company is installing our type "B" stokers with a double clinker grinder. The United Electric Light & Power Company will have twelve 1890-horse-power boilers, each equipped with two 14-retort Taylor stokers, double set, with clinker grinders between them, arranged in a manner similar to the Detroit Edison installations.

We find that one type of Taylor stoker cannot meet all installation conditions, and we have developed seven distinctive modifications of the original Taylor stoker, to meet the various conditions existing throughout the country, and to fit the various power-plant lay-outs.

MR. T. A. PEEBLES:* I have made some notes on Mr. Rahm's nine criticisms of the traveling-grate stoker as applied to burning coke breeze.

1. That the forced-draft traveling grate will not burn bituminous coal. The statement made by Mr. Worker, which was quoted in support of this contention, was made in April, 1919, and I doubt if Mr. Worker would confirm the same statement to-day in view of the work that has been done during the past 18 months. Furthermore, the tests to which Mr. Worker referred were not run on a forced-blast traveling grate but on the familiar type of natural-draft, chain-grate stoker to which forced blast had been applied. A natural-draft, chain-grate will not give satisfactory results on forced draft any more than a forced-draft stoker will give good results with natural draft. There are to-day about 250 forced-blast, traveling-grate stokers in the United States, burning all grades of bituminous coal—including coking coal, Illinois coal, Texas and Colorado lignites—and all are giving good results.

2. That a large grate area is required. This is necessary to get ratings out of coke breeze, for two reasons. Coke breeze is a low-grade fuel; it contains practically no volatile matter and is, therefore, slow burning. A combustion rate of 30 pounds per square foot of grate surface per hour with coke breeze requires the burning of as much fixed carbon as would be required when burning coal at a combustion rate of from 50 to 55 pounds per square foot per hour. In the second place, it is not a question of burning coke breeze but of keeping it in the furnace. Coke breeze can be ignited at very much higher rates than it can be burned in commercial operation for the reason that at high combustion rates a large percentage of fine dust is carried away by the furnace gases. This condition, rather than the ability to ignite the fuel, limits the unit combustion rates.

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*Chief Engineer, The Hagan Corporation, Pittsburgh.

3. That the fuel bed must be carefully watched to maintain proper depth, etc. In the operation of a stoker of this kind, it is customary to establish the thickness of fire best suited to the fuel and to maintain this thickness under all conditions of operation. Large variations in rating are taken care of by increasing the length of fire and regulating the air supply accordingly, rather than by changing the thickness of the fuel bed.

4. That long, low combustion arches are required. If an arch must be low, it can not be made long. Combustion arches of the latest design are placed approximately four feet from the grate at the point of ignition and six feet, or more, at the other end. A long, low combustion arch will not ignite coke breeze satisfactorily. There is also the problem that the arch cuts off radiant heat. Tests run on this type of stoker do not show appreciably higher escaping gas temperatures than tests under similar conditions on stokers not requiring an arch. It is immaterial how the boiler absorbs the heat so long as the absorption is actually secured.

5. That forced-blast traveling grates can not meet varying load conditions or carry heavy overloads. Under normal conditions of operation, this type of stoker will have three or four feet of grate surface at the rear which is practically inactive and to which no air is being supplied. In the case of an increase in load, the stoker can be speeded up and air supplied to the rear sections; at the same time, the air supply to the other sections can be increased and the rating increased quite rapidly. Any desired rating can be obtained because the design of stoker is such that very large grate areas can be installed. The fire is not affected by ash accumulations and high ratings can, therefore, be carried for long periods of time.

6. That the abrasive nature of coke breeze causes rapid wear. The coke breeze is very abrasive but the wear comes on those parts where there is relative motion between the coke breeze and the stoker parts. This occurs only in the fuel hopper. The grate surface itself simply carries the breeze through the furnace and there is no opportunity for abrasion to occur. Underfeed stokers, in which there is relative motion between the coke breeze and the retorts, are subject to rapid abrasion, and heavy up-keep costs will result.

7. That the blow-pipe action on the tubes, due to the long, low arch construction, is objectionable. It is common practice, with this type of stoker, to design the furnace so that the gas velocity at the rear of the arch will not exceed 30 feet per second, and at this velocity there will be no blow-pipe action. There is room for argument as to whether or not the concentration of heat would be objectionable, provided the boiler tubes were kept reasonably clean, but even admitting that such action would be injurious to tubes, the criticism is not applicable in the case of gas velocities, which never exceed 30 feet per second. The forced-blast traveling grate differs materially from the natural-draft, chain-grate stoker. With the forced-blast machine, there is no bridge-wall over-hang required to cut off air leakage at the rear, since the air supply is under control. The bridge wall is set back 12 or 18 inches from the rear of the stoker and therefore does not come into contact with the hot gases. The hot gases are, therefore, not forced into the tubes at the bend and severe conditions do not result.

8. That the fire is uneven and irregular. This condition will result if uniform coke breeze is not supplied. Bituminous coal passing through a 1.5-inch screen makes a good stoker fuel but coke breeze must be considerably finer and should pass through a ⅝-inch or ¾-inch round screen. Those plants securing irregular fires at the rear are attempting to burn breeze having particles much larger than ¾ inch.

9. That local conditions often make this type of stoker undesirable. This is true of all stokers and can not be offered as a criticism of any one type.

In general, it may be said that there are approximately one million boiler horse-power being developed by stokers of this kind burning all grades of fuel. There are about eighteen hundred such machines in operation and several large power-plants have recently made installations for the burning of low-grade bituminous coal. A few years ago, the natural-draft, chain-grate stoker was looked upon with great favor for burning all types of coal, except those with strong caking tendencies. The underfeed stoker has developed to the point where there was every indication that the chain-grate type would become obsolete except for small installations, but the application of forced blast has completely changed the performance of the traveling grate and there is every indication that it is coming back into favor.

MR. R. J. HORNE:* Mr. Peebles referred to the statement quoted in the paper from Mr. Daniels's report, to the effect that grate area is not of great importance in an underfeed stoker. It occurs to me that such a statement is erroneous. For example, take an extreme case where you have a very small fuel bed under a very large boiler. It would not be possible to get out of the boiler the capacity that you would get with a proportionately larger fuel bed.

As brought out by the paper, combustion depends upon feeding sufficient fuel, and supplying sufficient air; but, further than this, sufficient space must be provided to burn the fuel and to admit the fresh fuel and air. The incoming air can not have too high a velocity or the fuel bed will be disturbed; so that it comes down to a matter of having sufficient grate area for properly supporting the fuel and combustion.

In describing the Westinghouse underfeed stoker, Mr. Rahm pointed out that air is supplied to the dumping grates just before the ashes are dumped. I wish to correct this statement to the extent of saying that air is supplied to the dump grates whenever there is considerable combustible in the ash. This condition prevails when the stoker is operating at high overloads and at such times air is supplied to the dump grates continuously. At overloads the fuel is being fed faster than it can be completely burned on the underfeed or overfeed sections so that by admitting air to the dump grates we virtually increase our grate area and obtain efficient combustion at the higher overloads.

The admission of air to the underfeed, overfeed, and dump-grate sections is under selective damper control so that coals with different burning characteristics can be supplied with air in the proper amount to meet their peculiar needs. Another advantage of this arrangement is that the operator can regulate the air supply to the various parts of the fuel bed as necessitated by the condition of the fire.

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*Engineer, Stoker Section, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

I would like to ask Mr. Peebles how sifting of coke breeze through his chain-grate stoker is taken care of.

Mr. T. A. Peebles: A comparatively small amount of fuel sifts through the grate surface. In some plants, the sifting boxes are cleaned every day, and in other plants once a week. The interval between cleanings is determined by operating conditions and the fineness and moisture content of the fuel. Some plants prefer to establish a regular cleaning period while others clean only at such intervals as an inspection shows to be necessary.

Mr. Joseph Breslove:* I think that possibly the average user of stokers is a bit reticent in discussing his particular stoker with the prospective customer who has inquired as to his experience. The general answer is "We have had wonderful success with these stokers. They have cost us very little to operate and if we were going to buy another stoker this is what we would buy." That is the truth; but there is frequently a long history between the time the stoker was purchased and the time you would buy another of the same kind. This is due to the difference in the various coals encountered and to other local condtions which cannot always be foreseen. I have been fortunate, or unfortunate, in having had stokers of that kind, and while Mr. Rahm has modestly refrained from making comparisons of the various stokers there is no doubt that certain exclusive features possessed by one type or another may prove of value for the particular case.

In two plants in the coal fields we are trying to burn a bone coal. This coal itself is not bad if you can get rid of the slate. It contains three to six per cent. sulphur—usually 3.5 per cent.—and does not clinker badly. Without excessive quantities of slate the ash content is 25 to 30 per cent. and the B.t.u. value about 11,000 to 12,000. But this slate comes over in large and irregular quantities, at times, and there is, unfortunately, no way of closely regulating the slate content. The result is that you may have very good coal at one time, and the next moment have the equivalent of about 60 per cent. ash. We decided to install underfeed stokers and try out some of this material. Efficiency is not so important because what is not burned is thrown out on the rock dump. We purchased the new Jones "AC" stokers and have had a fair degree of success with them up to the present. We were probably among the first to use this stoker for bone coal. At the time they were bought, the forced-draft, chain-grate stoker was not so well known or we would probably have considered that type quite seriously. In analyzing the stoker it has, to use the manufacturer's slogan, "extreme simplicity." There are practically no moving parts. It is accessible from both the front and sides and requires somewhat less head-room than a couple of the other well known and successful underfeed stokers.

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*Consulting Engineer, Pittsburgh.

We encountered various difficulties, one of them being that a sudden slug of bone or slate would chill the fire quite rapidly and what was a good fire one minute would become black the next. The slate must, of course, be brought up to the furnace temperature which, therefore, absorbs considerable heat from the fuel bed. This retards combustion at the front end of the furnace and coking takes place further along than when burning a good grade of bituminous coal. It is fairly coked about the time it reaches the dump plate and tries to burn thereon, sometimes with disastrous results to the dump plates. Crushing the coal down smaller than what is ordinarily considered good practice so as to expose every particle of coal adhering to the slate, and installing extra long retorts, is desirable for this condition. We are now successfully burning a mixture of about 80 per cent. bone coal and 20 per cent. good bituminous coal and expect shortly to burn bone coal entirely.

This leads me to a sort of comparison of the various types which may prove interesting. We have at another plant type "E" stokers with side dumps. This type possesses the feature of alternate moving and stationary grate-bars which slightly agitate the fuel bed and which appear to have considerable merit for certain kinds of fuel. We are burning road cleanings and "bottom coal" with this stoker. By carrying light draft and thin fire we successfully burn these cleanings which consist of sand, dust, slate and about 75 per cent. coal. We have also burned this coal on the Jones "AC" stoker. The Riley stoker also possesses the moving grate-bars, in this case brought about by a suitable movement of the tuyeres, while the Taylor also agitates the fuel bed but in a slightly different manner. Both the Westinghouse and Jones stokers use the side-wall tuyeres, which reduce the side-wall clinkering. I believe the Westinghouse Company is the only one using an air-cooled dump and, for coals which do not ignite quickly and consequently tend to coke towards the rear end of the furnace, this is a valuable feature in protecting the dump plate.

Mr. Rahm stated that grate area is not of much importance in the underfeed stoker. Maybe not until you come to buy it. I believe underfeed stoker manufacturers base their price directly on grate area. A curve drawn between grate area and the price is a straight line.

With the advent of the poorer grades of fuel, I feel that some of the characteristics of the future stoker will be greater length of retort and furnace so as to increase the time element, zoning of the air draft, side-wall tuyeres and an air-cooled dump, and, for burning certain grades of semi-bituminous coals, coke breeze and slow burning fuels, the forced-draft, chain-grate is also well worthy of serious consideration.

Mr. Edward Rahm, Jr.: Mr. Peebles has made a very able and interesting defense of the forced-draft, chain-grate stoker. I think that he is a little optimistic regarding the ability of this type of stoker to burn bituminous coal. The distillation of the volatile matter cannot be nearly as efficient or as well distributed.

Regarding the long combustion arches over. the forced-draft, chain-grate I spoke from actual experience. Mr. Peebles states that forced-draft chain grates are designed to give a gas velocity of about 30 feet per second at the end of the arch under normal conditions and that this velocity would not have any of the previously mentioned blow-pipe effect. This may be the case under normal conditions but, when running at high ratings, the blow-pipe effect caused by the arch concentrating the heat on the lower part of the tubes on a bent-tube boiler becomes very evident. I have seen a number of tube failures the cause of which was ascribed to this blow-pipe action of the gases over a forced-draft chain-grate type of stoker.

Mr. H. N. Scofield: I understood Mr. Peebles to speak of the high efficiencies of the forced-draft, chain-grate type at high ratings. Can he give us any idea of the efficiency of these grates at lower ratings, as compared with their efficiency at high ratings?

MR. T. A. PEEBLES: The efficiency curve takes a shape very similar to that shown for the Westinghouse stoker. It is possible to establish a combustion rate which is satisfactory for a particular fuel and then to increase or decrease the length of the active grate surface with changes in rating. It is, therefore, not necessary to increase the combustion rate per square foot in proportion to the increase in rating and this makes it possible to secure a very flat capacity-efficiency curve.

MR. H. N. SCOFIELD: Then I judge the condition is that in regular operation you cannot get a high efficiency at more than one point.

MR. T. A. PEEBLES: The stoker is not limited to one rating. Both the rate of combustion and the active grate area can be varied to suit load variations.

MR. H. N. SCOFIELD: But that range does not nearly approach the range of an underfeed stoker. My point is, that with a properly designed underfeed stoker, you automatically get a comparatively flat efficiency curve over a wide range of ratings. With a forced-draft, chain-grate type, if it can be obtained at all, this flat curve is possible only by careful adjustment of drafts in the various grate sections, as Mr. Peebles describes, and I doubt whether the average fireman is capable of this.

MR. F. F. ESPENSCHIED:* I think the different speakers have different things in mind. When Mr. Peebles speaks of combustion per square foot, I think he means per square foot of actual fire, because the traveling grate to which he refers—that is, the well known Coxe stoker—is not usually entirely covered with fire. If a higher boiler rating is required, the length of fire is increased by speeding up the grate. This does not materially increase the combustion rate per active square foot, but more square feet of the grate are in use. I think that is where the two gentlemen do not quite agree. The combustion rate per square foot of stoker installed does vary, but the combustion rate per active square foot in use (fire area) does not vary materially with the given fuel and other conditions. As has been pointed out, experience has shown that for increased loads, the grate speed is increased leaving the gate or coal feed or fire thickness practically constant. The Coxe traveling grate, with sectional wind boxes, we believe, was the pioneer stoker to utilize this principle, and its superiority over the usual chain grate is largely due to its ability efficiently to utilize different lengths of fire without introducing large excesses of air at the rear end, as is the case with the ordinary chain grate when the fire is shortened.

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*Power Engineer, W. E. Moore & Co., Pittsburgh.

Mr. T. A. Peebles: May I say a word in regard to Mr. Rahm's last remarks? I will admit that the underfeed stoker will burn certain bituminous coals better than a forced-blast traveling grate. I claim, however, that there are certain bituminous coals that the forced-blast traveling grate will burn better than the underfeed stoker.

Regarding the blow-pipe action—I do not believe gases traveling at 30 feet a second, or less, will produce such an effect. With a setting such as Mr. Rahm has shown for the chain-grate stoker, this condition might possibly occur, but with a forced-blast traveling grate, the arches are set considerably higher than shown, the bridge wall is set back two or three feet farther, and the gases are not directed at the bend in the tubes.

It is well known that coke breeze burns best when it is of fairly uniform size. If a substantial percentage of the fuel consists of lumps of from 1 to 1.5 inches, the economy will be affected but high capacities can still be secured. Where efficiency is a factor, only those sizes below 5/8 or 3/4 inch should go to the stoker. If there is an unlimited supply of breeze available, and capacity is the only thing desired, the coarser particles can also be burned.

Mr. Edward Rahm, Jr.: I have no criticism to make of the remarks made by Mr. Horne of the Westinghouse Electric & Manufacturing Company, but, as a general thing, I would not advocate burning the coal on the dump plate, as the coal should be burned in the main body of the retort, and the ashes and clinkers come on to the dump plate. In certain cases, with coals of a specific nature, I would arrange it so that the coal could be burned on the dump plate, and in a few instances this has been done on the Jones "AC" type of stoker by putting in an auxiliary air supply and control at the dump plate.

It is rather interesting to notice from Mr. Scofield's remarks that the American Engineering Company found it necessary to develop seven distinct types of stoker to meet various conditions existing throughout the country, and this is caused by the design of the stoker having been changed to handle the different kinds of fuel. It is my experience that with a Jones "AC" type of stoker all grades of fuel can be handled quite successfully with two lengths of retorts, the stoker being practically the same design—and, on this stoker, Nova Scotia coal, New Brunswick coal, bone coal, free-burning coals of the Middle West, semi-bituminous coals of Utah and lignites of Washington have been burned.

In regard to the remarks by Mr. Peebles, in my paper I merely brought up the point that it seemed to be the general opinion that only coke breeze should be burned on the new design of chain-grate stoker, and did not intend to go into a discussion of the burning of different kinds of fuel on forced-draft, chain grates, but reply to Mr. Peebles' statements as he brings them up as follows:

1. The forced-draft, chain-grate stoker has yet to prove its ability to handle bituminous coal successfully. One of the established chain-grate stoker companies has admitted the inability of the chain-grate stoker to handle eastern coal successfully, and has brought out a very much modified form of stoker, which it is claimed will handle eastern coal. We understand that two or three installations have been made, but this equipment is yet in the nature of an experiment.

2. In his argument Mr. Peebles admits that a large grate area is required for a forced-draft, chain-grate stoker to handle coke breeze successfully, which substantiates the point made.

3. Mr. Peebles overlooks the fact that in addition to the depth of the fuel bed, I also mentioned that the travel of the fuel bed and the varying air pressures in the different air zones ought

to be watched. Although he admits that the length of the fire has to be regulated and the air supply changed, we all know that all three factors enter in, and with varying loads require constant attention.

4. By a long, low, combustion arch we mean an arch that projects into the furnace a considerable distance and one which is "licked by the flames." With the chain-grate stoker, either natural or forced draft, where heavy ratings are carried, the arch maintenance is a very heavy expense, and the radiation of heat is a factor.

5. When we speak of varying loads, we mean those where the boiler must go from rating to 200 or 250 per cent. of rating in from five to eight minutes. Mr. Peebles states that under normal conditions of operation, three or four feet of grate surface at the rear is practically inactive. This would mean, we believe, that there is practically no combustion at this point. It must necessarily take several minutes to get a good live bed of glowing coal over the entire grate surface, and this is essential before heavy overloads can be secured. We cannot agree that the fire is not affected by the ash accumulation, as this is plainly evident with any type of stoker. If it were not, it would be just as easy to maintain a good fire regardless of the ash content of the fuel, and this we know is impossible.

6. Where coke breeze is burned, there is a fine abrasive dust which affects the working parts, and causes wear on the stoker-driving mechanism where this is exposed. In the chain-grate stoker, where comparatively thin fuel beds are carried with coke breeze, and where an intense heat is necessary to secure higher boiler ratings, a heavy maintenance expense follows. With the underfeed stokers burning coke breeze, the green fuel being fed up from beneath protects the tuyere blocks, grates, etc.

7. I spoke from experience on this point, and anyone familiar with combustion knows there is a tendency to concentrate the heat at one section of the boiler tubes where long arches are used. Possibly this will do no damage if the boiler tubes are kept clean, but how many plants keep their boiler tubes as clean as they should? We submit that it is better practice to distribute the heat over the tubes as much as possible.

8. On this point Mr. Peebles proves the necessity of having uniform fuel with the forced-draft, chain-grate stoker. This is not essential with the underfeed type.

9. I believe that Mr. Peebles misstates this point. The statement is, "Local conditions *sometimes* make the installation of this type of stoker impracticable." The writer did not say *"often,"* but *"sometimes."* In explanation, we agree that local conditions *sometimes* make the installation of any stoker impracticable, and in many other cases local conditions govern the selection of stoker equipment.

Referring to all the remarks, in general—we believe combustion engineers familiar with stoker operation are well aware that the forced-draft, chain-grate stoker has shown its ability to handle anthracite and coke breeze. We do not understand that any underfeed company at the present time claims complete success with its stokers with either of these fuels alone, although several have successfully burned these coals with varying mixtures of bituminous coal.

From data submitted on the forced-draft, chain-grate stoker, "which data is meager enough" there is little to prove the assertion that these stokers are able to maintain the heavy overloads of the underfeed stoker. They do not possess the high flexibility of the underfeed stoker; more attention is needed in the operation of their several air controls; and the stoker necessitates not only a great many more parts, but also a larger grate area, combustion arches, and water backs. These latter features are not necessary with underfeed stokers. We submit the opinion that any stoker not requiring such equipment possesses distinct advantages.

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37 MARCH 1921 No. 2

PROCEEDINGS

OF THE

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

COAL-MINE EXPLOSIONS - - - - - - - *James W. Paul*

SOME PROBLEMS ENCOUNTERED IN WATERWORKS ENGINEERING *W. C. Hawley*

PITTSBURGH
UNION ARCADE BUILDING

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COAL-MINE EXPLOSIONS*

By JAMES W. PAUL†

It has become a custom for the retiring chairman of a Section of this Society to deliver an address at the close of his term of office and I offer this in explanation of my being on the program for this evening's meeting of the Metallurgical and Mining Section.

For the benefit of the many mining engineers, mine officials and inspectors who are members of this Society, I have chosen for my address a subject that has heretofore been given little space in the published PROCEEDINGS of the Society. The information contained in this address has been taken largely from various United States Bureau of Mines publications that have appeared during the past 10 years, and an attempt is made to present this subject matter in the nature of a summary of the important factors and conditions that govern in coal-dust explosion, and methods that control or stop explosions of coal-dust in bituminous mines.

When we speak of coal-mine explosions we refer to the physical manifestations within a mine, resulting from the rapid combustion of a mixture of air and methane or coal-dust and there are records of mine explosions as far back as are the records of coal mining.

The early explosions were all charged to the presence of methane that had accumulated owing to improper ventilation arrangements or inadequate facilities.

In the early part of the last century it was observed that fine coal-dust was found in exploded mines in a charred and cooked condition, and it was assumed that the flame and heat of the gas explosion was responsible for this altered condition of the dust; but as ventilation methods were improved it was noticed that charred dust was found in parts of mines where the ventilation current was supposed to be free from the influence of gas, and this condition naturally led to more careful observation of the phenomena of explosions with the result that coal-dust was charged with being responsible for extending throughout the mine an explosion that had its origin in gas.

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†Chief of Coal Mining Investigation, Pittsburgh Experiment Station, U. S. Bureau of Mines.

It is not the purpose to give here the history of the progress of the study of mine explosions, but to bring attention to some of the salient features involved in a scientific study of mine explosions and some methods evolved to control or prevent explosions.

Occurrence of Explosions. Gas explosions have occurred in salt-mines, in iron-ore mines, in subterranean tunnels and in coal-mines, all from the intrusion of methane into the excavations.

All nations that are factors in coal mining have from time to time been shocked by the occurrence of explosions in coal mines, but due to the scientific study by the leading nations, the occurrence of such explosions is becoming very much less frequent, and, where rigid discipline is enforced and modern appliances and practices are installed, there is little probability of the occurrence of a general explosion throughout the mine.

European governments have some advantage over the United States, to the extent that they may require by law or regulation the adoption of such remedies as are suggested by the result of their scientific investigations; whereas in the United States the government has no police authority in the states to enforce such recommendations as may result from its investigation. However, this has not been any great barrier to the adoption of many of the recommendations that have been made as a result of the investigations made regarding mining hazards.

No other country has gone into the study and investigation of mine explosions more thoroughly or on so large a scale as the United States through the Bureau of Mines. These investigations were taken up by our government in 1908, and tests conducted in a steel gallery until October, 1911, when the experimental mine became available for tests.

Gas and Dust as Factors. There may be explosions due to the presence of gas alone, with coal-dust alone, or due to the presence of both, when mixed with air.

In a wet or dustless mine a gas explosion will travel only so far as sufficient gas is present to support combustion; consequently, gas explosions are localized in many mines where coal-dust does not enter into the reaction. A gas explosion may cause damage beyond the zone of its combustion, by shock and pressure waves traveling to other sections of the mine, and thus destroy ventilation over a large section of the mine. The after-damp from the explosion may thus take toll of lives of persons trapped by the gases.

Tests of bituminous and sub-bituminous coal having 10 per cent. or more of volatile matter are susceptible to explosion when thrown into suspension in the air. The higher the percentage of volatile matter, the more easily is the dust cloud ignited.

Source of Ignition. Ordinary bituminous coal-dust when thrown into a cloud may be inflamed by the application of a lighted torch, or other source of heat such as hot metal. Such a cloud must have a relatively high density—too dense for the eye to penetrate sufficiently to see objects.

In experimental tests in a large steel gallery it has been found that as little as 0.032 ounce of coal dust per cubic foot of space is sufficient to give an explosion when ignited.

In mines, such dense clouds of dust may result from falls of the roof, from wrecks of mine-cars when in motion, from blown-out shots, and from local gas explosions. When such a cloud is formed it may be ignited from an open-flame torch, an electric arc, the flame of a gas explosion, or the flame of a blown-out or overcharged shot of powder. The ignition of most dust explosions is caused by overcharged or blown-out shots using black blasting powder.

Under certain conditions the inflammation of the coal-dust may be confined locally and where such inflammation occurs in some mines it is designated as a "windy shot." A true ignition, however, is one that results in an inflammation that gives sufficient pressure and velocity to raise additional clouds of dust and communicate flame to the clouds of dust.

In experimental mine tests it has been shown that if true inflammation is obtained it will travel 350 feet along the entry that is about six by nine feet in section. If the inflammation stops short of 350 feet it is considered that ignition has not been obtained, since the nature of the dust is such that it will not support flame after receiving its initial impulse from the cannon shot. In all ignition tests, the coal-dust is mixed with a certain percentage of rock dust and the mixture is distributed from immediately in front of the cannon for a distance of 350 feet along the entry.

Propagation of Explosion. An explosion is said to propagate when the mixture of air and dust is such that it is self supporting in its explosibility after having received the impulse of an explosion equivalent in intensity to an explosive mixture of natural gas and air occupying 50 feet of the entry in the experimental mine. In practice it has been found that pulverized Pittsburgh coal distributed in the 50 feet of the entry, when fired by a blown-out shot from the cannon, is equal in intensity to an explosive mixture of gas and air confined in the same space.

In conducting tests for propagation, the dust is distributed along the two parallel entries, a distance of 300 feet, and through the last break through, a distance of 50 feet. If the explosion passes through this zone it is said to propagate; whereas, if it fails to travel through the zone, it is said to fail to propagate. Almost all bituminous coal-dust in its natural state will give ignition and propagation in the experimental mine.

To determine what mixture of rock dust and coal-dust will not give ignition and propagation, experiments are made with mixtures until the right amount of rock dust is added to prevent ignition and propagation. With dust made from the coal in the experimental mine it has been found that 40 to 60 per cent. of rock dust is required to prevent ignition, and 60 to 75 per cent. to prevent propagation when the air is free from explosive gas.

With Pittsburgh coal-dust the explosibility limits are as follows:

1. With 20-mesh dust (20 per cent. through 200 mesh) which is about normal road dust.

   Non-propagation with 40 coal and 60 shale (no gas).
   Propagation with 50 coal and 50 shale (no gas).
   Non-ignition with 60 coal and 40 shale (no gas).
   Ignition with 70 coal and 30 shale (no gas).

2. With pulverized dust (all through 100 mesh, 85 per cent. through 200 mesh).
   Non-propagation with 25 coal and 75 shale (no gas).
   Propagation with 30 coal and 70 shale (no gas).
   Non-ignition with 40 coal and 60 shale (no gas), this point being on the line. Out of seven trials, ignition was obtained once and failed six times.
   Ignition with 50 coal and 50 shale (no gas).

To overcome the presence of one per cent. gas it is necessary to increase the shale five to eight per cent.

Velocities. The velocity of the flame of an explosion is readily measured electrically by the use of a chronograph. This is accomplished by arranging electric circuits that are broken by the heat of the flame of the explosion as the flame passes fixed stations. The zero point is made by the breaking of a wire stretched across the mouth of the cannon, and the fixed stations are provided with a tin-foil strip that melts when the flame passes it. The chronograph is mounted in the observation room at a safe distance from the mine. The time on the chronograph is indicated by a pen bearing against smoked paper and the pen is made to vibrate 100 times per second by means of a tuning fork. The chronograph also records the shock wave, as well as the reversals of air movements and the explosion wave.

In general, the velocity of a dust explosion is relatively slow over the first 50 to 100 feet from its origin, but it quickly increases and within the next 200 feet may attain a velocity of 500 feet per second. In some tests the velocity has reached 3000 feet per second, and higher, with a corresponding increase in pressure.

Dust explosions at their origin do little damage when compared with the physical destruction along the path of the explosion and in other parts of the mine, thus it is not safe to select the point of greatest destruction as being the origin of the explosion.

Pressures. The pressure developed in the course of an explosion depends upon the rapidity of combustion of the dust, and the size and character of the excavation through which the explosion passes. It ranges from two pounds up to 120 pounds per square inch on the sides of the mine entries. The pressures are recorded at fixed stations placed in the rib of the coal and protected by heavy iron plates.

The record is obtained photographically by the reflection of an electric light through a small mirror that is tilted by pressure exerted by the air and gases against a diaphragm that has previously been calibrated. An aperture through the protection plate admits of photographing the flame as it passes.

Shock Wave. From the initial explosion, such as a blown-out shot, there is sent out a wave that precedes the explosion wave and is of such force as to break doors and wooden stoppings, and which also stirs up dust clouds. This shock wave has a velocity as high as 1100 feet per second; its velocity, under the conditions then obtaining, being that of sound.

Explosion Wave. The explosion wave is the movement of the flame and hot gases that constitute the chemical reaction in the explosion, and the flame has the appearance of a cone with its apex in the lead, the flame in the center traveling in advance of the flame near the top, sides, and bottom. The body of air through which the explosion is passing may also be in motion as the result of the pressure set up by the oncoming explosion and the expansion of the gases.

Retonation Wave. As previously stated, an advancing explosion will build up pressure and at times this pressure becomes so great that the gases in the rear of the explosion wave are driven back with a high velocity and a second pressure wave will be recorded at a fixed station. This is known as a retonation wave and is capable of doing much physical violence.

This is different from the recoil or backlash that results from the cooling of the hot gases. From the action of retonation waves, material that had been blown in one direction by the explosion wave, may be blown in the opposite direction. It has often occurred after explosions that originated at the head of an entry, that cars, props, and material have been carried several hundred feet and lodged against the head of the same entry, thus practically covering up its tracks to the confusion of the investigator who is seeking the origin of the explosion.

Air Movements. The main body of air that moves in the direction of the explosion wave may be recorded as to its direction. This is accomplished by a strong metal vane suspended from the rib and fixed to a shaft that makes and breaks electric contacts that are recorded on the chronograph. After the passage of the explosion wave, the vane may move backward and forward a number of times, depending upon the retonation waves and the recoil due to the gases cooling.

Character of Explosive Dusts. Bituminous coal-dust coarser than 20 mesh does not enter into an explosion, but dust finer than 20 mesh is active and will explode under favorable conditions. As the dust is finer it becomes more sensitive to ignition and explodes with greater violence.

Much dust found in coal mines is of such a character that 20 per cent. will pass through 100-mesh screen and this produces a strong explosion under test conditions. Dust from the Pittsburgh coal in the experimental mine, when reduced so that it will all pass through 100 mesh and 85 per cent. through 200 mesh, will give an ignition that is equal in violence to an explosive mixture of natural gas and air.

Dusts other than coal-dust will explode. Grain dust, flour, starch, and flour of sulphur will explode under conditions similar to those producing explosion of coal-dust. When raised in a cloud starch produces an explosion with a violence much greater than that of coal-dust. A prerequisite of a dust explosion is that the dust be raised in a cloud in the air. Lycopodium, aluminum dust, and charcoal dust have been exploded when blown into a cloud in the presence of flame.

Phenomena of Explosion. Coal-dust *per se* is not explosive as is gunpowder. When the coal-dust is raised into a cloud of proper density it may be inflamed by the application of a flame, and if in a confined space may burn with such rapidity as to simulate an explosion. When in a confined space it may be made to explode by an ignition that projects some energy into the dust-and-air mixture, such as firing a blank cartridge into a small quantity of powder, the flame of which ignites the coal-dust. Just what transpires in a coal-dust explosion is not as yet known to the satisfaction of all investigators. Coal-dusts having less than 10 per cent. volatile hydrocarbons do not explode and coke dust having less than 10 per cent. volatile gases does not form an explosive mixture with air; but some investigators report having exploded charcoal dust that has practically no volatile gases.

There is a school of investigators which claims that the solid particle of dust is consumed by the surrounding air, while another claims that the volatile gases are first distilled from the coal-dust particles and the gas thus set free forms the main combustible. While this is an interesting problem for scientific investigation, it is doubtful if its solution will result in the abatement of coal-dust explosions.

Prevention and Control of Explosions. In order that dust may become an explosive agent, it must be brought into suspension in the air. Any agency that will prevent the dust within a mine from becoming suspended in the air will prevent a dust explosion. The only method that will prevent dust from being thrown into the air is the application of water to all surfaces within the mine, and in such quantity as to maintain the dust in a plastic state at all times. Pittsburgh coal-dust requires about 30 per cent. water to prevent it from exploding when blown into the air by an explosion wave.

In many mines the use of water may not be adapted to the local conditions, such as a soft clay bottom and a shale roof that disintegrates upon the application of water. Under such conditions other remedies are available, less costly and more lasting.

Inert Material. If coal-dust is mixed with some inert dust such as powdered rock, shale, or limestone, the inert dust will absorb sufficient heat to prevent the coal from being inflamed. The quantity of inert dust required depends upon the chemical and physical characteristics of the coal-dust. For coal-dusts having practically the same analysis, the proportion is approximately the same, but it requires an actual test to determine the exact proportion.

Rock Dust and Dust Barriers. For practical use in mines the rock dust should be made from a material that is free from, or low in, carbonaceous material, and should be ground to a fineness such that all of it will pass through a 20-mesh sieve and at least 30 per cent. will pass through 100 mesh. In practice, some mines use a rock dust 95 per cent. of which will pass through 200 mesh. The rock from which the dust is made should be free from angular and needle-like quartz, since by inhalation such dust particles are liable to find lodgment in the lungs and cause pulmonary trouble.

The methods adopted for the use of rock dust consist of the application on the roof, sides, and floor, using one to two pounds per lineal foot of the entry. The first application is thrown on by hand, and subsequent renewals may be made by blowing on by machine, but an air blast is not the most efficient since the rebound of the air carries away some of the dust. Some mechanical throwing device for this purpose is very much needed.

Another method is the use of rock-dust barriers which are intended to isolate an explosion to some section or panel in the mine. This barrier consists of containers, boxes, or troughs that are placed overhead near the roof and so arranged that the rock dust contained in them is spilled immediately in front of an explosion wave. The quantity of dust required usually amounts to about two tons and the boxes are so designed that with a weak explosion the dust spills out for a number of seconds. In violent explosions the boxes are destroyed and the whole quantity of rock dust is then thrown into suspension and quenches the flame of the explosion.

The Chief Mining Engineer of the United States Bureau of Mines, Mr. G. S. Rice, has designed a number of rock-dust barriers that have proven very effective in stopping explosions in the experimental mine. See Fig. 1–2, furnished by courtesy of the United States Bureau of Mines. Fig. 1 shows how the dust is protected from moisture, by oil-cloth covers.

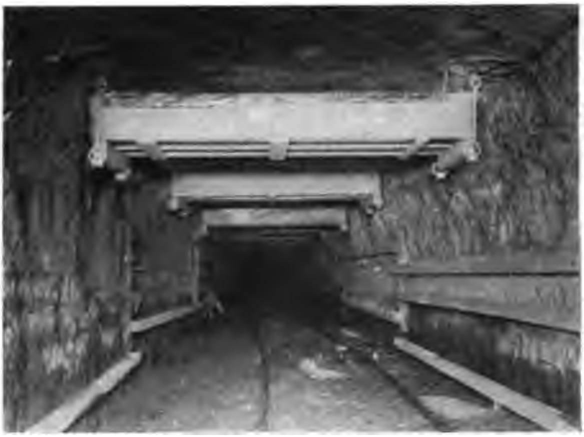

Fig. 1. Rice Rock-Dust, Box Barrier in Place in Mine Entry.

Other Preventive Measures. In addition to the use of rock dust as a means of stopping an explosion it is well to consider some of the precautions that may be taken to prevent the origin of an explosion, since prevention is conceded to be better than cure.

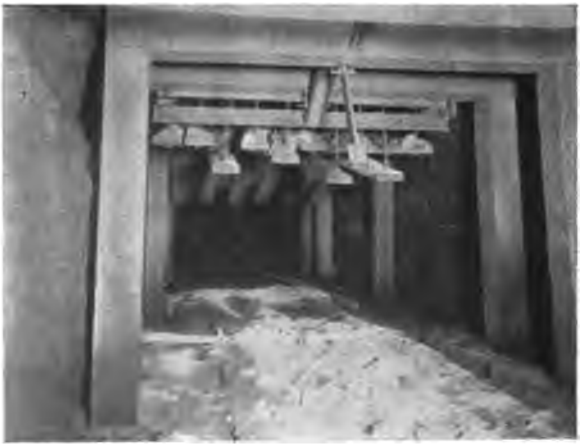

Fig. 2. Rice Type B, Concentrated Rock-Dust Barrier, After Being Tripped by a Weak Explosion.

Some of these, preventive measures prescribe as follows:

1. In gaseous mines, use closed lights.

2. In gaseous mines, restrict electric haulage motors to intake currents, and in other parts of the mine use only permissible or explosion-proof motors and switches.
3. In all mines, use permissible explosives.
4. In all mines, remove all coal-dust that may be obtainable with a shovel.
5. Use rock dust along all entries and in room necks, and at the entrance of panels install rock-dust barriers.
6. Adopt protection against mine fires, especially in a gaseous mine.
7. Insist upon rigid discipline among the employees.

For a further study of the subject there may be cited the following publications of the United States Bureau of Mines, under the authorship of Mr. G. S. Rice and his associates:

Bulletin 20. The Explosibility of Coal Dust. 1911.
Bulletin 44. First National Mine-Safety Demonstration; with a Chapter on the Explosion at the Experimental Mine. 1912.
Bulletin 56. First Series of Coal-Dust Explosion Tests in the Experimental Mine. 1913.
Miners' circular 3. Coal-Dust Explosions. 1912.
Miners' circular 21. What a Miner Can Do to Prevent Explosions of Gas and of Coal-Dust. 1915.
Technical paper 56. Notes on the Prevention of Dust and Gas Explosions in Coal Mines. 1913.
Technical paper 84. Methods of Preventing and Limiting Explosions in Coal Mines. 1915.

DISCUSSION

MR. JAMES W. PAUL, *Chairman*: It is customary when a paper is presented to the Section to place it before the meeting for discussion by those present. If any one wishes to ask any questions the author of the paper will endeavor to answer them to the best of his ability.

MR. WALTER GREENWOOD:* I would like to know how much longitudinal space is occupied by the shelving for holding pulverized rock used in making a dust barrier.

MR. JAMES W. PAUL: The concentrated barrier is practically as wide as the entry and is about 12 feet long and made in two sections. The ends of the boards are hinged in the middle so that they drop down from the middle, pointing inward and outward.

The troughs when used hold very much less dust. They are about 8 or 10 feet apart and 10 or 15 of them are used.

Another method, used in some mines, consists of putting shelves across the entry overhead and also putting rock dust on shelves along the sides; but in our tests we have found that some weak explosions will get by such barriers because the force is not sufficient to blow the dust off the shelves. We find that the troughs that are easily upset or the barriers that are thrown by a trigger are more certain in operation and throw the dust in suspension.

MR. WALTER GREENWOOD: In transferring pulverized coal to the point of consumption much of it usually escapes into the air and lodges on top of bins and on ledges of all kinds, even though the most approved methods yet devised are employed for handling it. What is the best method for removing this deposit without allowing it to get in suspension in the air?

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*Safety Engineer, Carnegie Steel Co., Youngstown, O.

MR. JAMES W. PAUL: In the transportation of pulverized coal every precaution should be taken to prevent any of it leaking from the transport lines into the air; and to prevent it from accumulating on ledges or elsewhere. Some plants use vacuum cleaners for taking up the dust in different parts where they do not have an installation to prevent the dust from getting into the air. If dust is allowed to accumulate on ledges and the tops of furnaces and such places, it may be dislodged and thus get into suspension in sufficient density so that if it comes in contact with hot metal or an open flame it is liable to produce an inflammation. We have records of quite a number of such explosions that have done considerable damage in the past, and injured and killed a number of men.

MR. WALTER GREENWOOD: What kind of an exhaust or suction system would be most suitable? Should the power be remotely located, or could a portable appliance with motor attached, be used?

MR. JAMES W. PAUL: A motor-driven exhaust system could be so installed as to prevent the electric features of the motor from coming in direct contact with the train of dust. It can be properly protected.

MR. WALTER GREENWOOD: Is inflammation likely to occur with such dust as floats in the air and accumulates on ledges in coal-crushing plants and storage bins, where sometimes the deposit is an inch or more in depth?

MR. JAMES W. PAUL: In the presence of an open flame there would be danger if men should be in the bin and there was an accumulation of fine coal-dust on the sides, or on lodgment places, and anything should cause that dust to be precipitated from its lodgment into the air and to come in contact with an open flame. There would be a probability of inflammation, and in the confined space of the bin it would be likely to do considerable damage. A number of inflammations in closed places have been caused by means of open lights, where men were handling the dry coal-dust. We have records of a number of men, in one case not far from Pittsburgh, severely burned, while handling fine coal in the presence of an open flame, but not in confined space. The coal-dust inflamed and four men were severely burned.

MR. WALTER GREENWOOD: It can be shown that in angular bins used for storage at the point of consumption, particularly if the bins slope on one or more sides, the coal will start to accumulate in the vertical angles, gradually building out until one or more sides are covered with a layer of considerable depth and area, packed so hard that water would have to be injected with much force to remove it. Sometimes these bins do not become entirely empty during a considerable period of time, and sometimes a considerable quantity is allowed to remain in the bins during a shut-down period. Is there much likelihood that coal will ignite spontaneously in such bins under the conditions mentioned? If there is, might it not be possible that when such combustion is in process the first arrival of a new supply of coal will ignite with possible serious results?

MR. JAMES W. PAUL: There are a number of cases of firing of powdered coal in the storage bin from which the supply is drawn. Some of these have resulted in inflammation of the dust that was being conveyed to the storage bin. And it has been found that where the coal is conveyed into the storage bin under certain conditions of temperature there is much probability of firing. After the temperature of the coal in the bin has reached 150 degrees F. it very rapidly takes on temperature through oxidation and is liable to result in what some would call spontaneous combustion; but it has had the initial heat through the drying process before the coal got into the bin, and it is necessary to exercise care and make observation in the storage bins to learn if the temperature does not exceed 150 degrees, because beyond that temperature the likelihood of further combustion is very probable.

MR. WALTER GREENWOOD: I have, from some source, gained the impression that a body of coal can become saturated with moisture precipitated from the air or drawn from the ground, and when thus saturated spontaneous combustion can occur. Is it possible for this to occur in bins, or would ignition be more likely to occur from fire traveling back through a burner from a furnace?

MR. JAMES W. PAUL: In the opinion of people who have been investigating spontaneous combustion of coal, the question is still debatable as to just what function moisture has in causing spontaneous combustion, other than to aid in decomposition. There are some engineers and chemists here who may have information or experience that would enable them to add something on this point, and we will be glad to hear from them.

MR. L. D. TRACY:* I think it is a pretty well known fact that a certain amount of moisture does not retard spontaneous combustion of fine coal. It has been practically determined that a temperature of 150 degrees F. is the danger point for stored coal. When coal is put in a bin at 150 degrees F. from the drier, no matter if there is a certain amount of moisture present, it will oxidize or heat just as rapidly as if it were put in dry. Sometimes, if the coal is overheated, it will, strangely enough, carry with it steam which on reaching the bins, conveyor, and feeders, condenses on the walls. Even then, if the coal stays in the bin a sufficient length of time, at a temperature of 150 degrees F., or more, the chances are favorable for spontaneous combustion.

There is one thing I should like to mention as one of the preventives of explosions in pulverized-coal plants, and that is absolute cleanliness. That is the essential thing. Some installations are now whitewashing, or painting white, the walls, machinery foundations and, in fact, very nearly everything about the building, as an aid in keeping the place clean.

In regard to the ventilaton of the pulverizing plant, it is essential to have a good ventilation system. But ventilation alone will not keep the place clean because there are corners and projections which the ventilating currents never reach. As Mr. Paul said, the better way to keep the plant clean is by a vacuum cleaner system such as is found in the larger buildings. In regard to motors, the only comparatively safe motor I have experienced about a pulverizing plant is what is known as the induction motor of the squirrel-cage type. In the squirrel-cage type of motor there is much less chance of sparking. I think the best system would be a central exhaust pump placed outside of the pulverizing building. Then pipe the building and attach flexible hose, fitted with suction cleaner nozzles, to the pipe connections—these connections to be placed at advantageous points throughout the building. I believe that this is done in grain mills, and in coal-crushing plants in France and Germany.

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*Coal Mining Engineer, U. S. Bureau of Mines, Pittsburgh.

It might interest you to know that we have a record of 10 explosions in coal-pulverizing plants with a loss of 15 lives and seven men badly burned. So pulverized coal is not only dangerous in a mine but also in pulverizing plants.

MR. A. C. FIELDNER:* In reference to the relation of moisture to spontaneous combustion, I believe that all experimental work that has been done on that subject tends to show that moisture is not a cause of spontaneous combustion, although, as Mr. Tracy has said, you may have spontaneous combustion in spite of the presence of moisture.

MR. L. D. TRACY: There is one point that I should like to bring out, and that is that the keystone of your safety arch (disregarding the open lights, hot metals, etc., which may be brought into a dusty room), is the drier. A drier must be properly constructed and properly operated to reduce the probability of coal-dust explosions. The cause of many of the explosions may be directly or indirectly traced to a faultily constructed or faultily operated drier. With such a drier you are liable to get red-hot coal in the pulverizer, and the moment that hot coal comes in contact with the dust in the pulverizer, conditions are exceedingly favorable for fire or an explosion. Or if you do not have one or the other in the pulverizer, you may, later on, in the pulverized-fuel bin or coal transport line. In one plant I know of, there was a serious explosion in the pulverizer, which wrecked it and raised a cloud of dust in the building, causing a secondary explosion almost immediately, badly damaging a 2½-story building probably 80 by 100 feet in size.

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*Supervising Chemist, Pittsburgh Experiment Station, U. S. Bureau of Mines.

MR. WALTER GREENWOOD: A case I have in mind could be accounted for on no other theory than that combustion occurred spontaneously. My belief in ignition occurring from such a cause is now somewhat shattered. In another case coal escaped from a small rupture in a container, and it was ignited from heat within the container. While I was trying to fit the theory of spontaneous combustion to this case, possibly I was wrong. Ignition has occurred at heating furnaces when receiving bins were filled too full and coal escaped at the top, coming in contact with fire in the furnace. It has occurred from fire traveling back through burners that choked at the discharge with coke formed by coal burning wthin the burner. In one case a canvas tube with the end closed—intended for a separator for escape of air used in forcing coal over from the pulverizing plant—burst and permitted a cloud of coal-dust to form and ignite from the furnace. This accident was due to a combination of bad conditions, all of which could not be foreseen.

I am particularly interested in the matter of safely handling pulverized coal, as I, along with others, have been appointed to formulate a set of rules to control the handling of it, and we now are hunting for data that will guide us in performing the work. It appears to me, as well as to others who have discussed the subject with me, that much improvement is yet to be made in equipment and methods employed in pulverizing coal for fuel, and in handling it after it is pulverized.

MR. L. D. TRACY: If you are using a pulverized-fuel system in which the pulverized coal is forced through a 12- to 16-inch pipe by a current of air from a fan, together with a secondary air line which furnishes sufficient additional air for proper combustion; and if the pressure in the primary air line, for any reason, falls below that in the secondary line, a back draft will be formed which will draw incandescent coal particles from the furnace and blow them into the coal transport line. At the time, there may be a thick cloud of dust, but not enough air to support complete combustion, but as the coal is drawn from the line, there may come a time when dust and air are in the proper proportion to cause an explosion.

MR. WALTER GREENWOOD: Coal is transferred from the pulverizing plant at McDonald Mills through a four-inch pipe, and the air pressure required to force it out of the scale bin is about 45 pounds. This pressure rapidly diminishes as the volume of coal in the storage bin decreases.

SOME PROBLEMS ENCOUNTERED IN WATERWORKS ENGINEERING

By W. C. Hawley*

The practice of engineering has been tending for a long time toward specialization. Originally engineers were of two classes—military and civil. Gradually civil engineers began to specialize and thus it came about that we had mechanical, mining, and electrical engineers, etc. The process of specialization has continued until we have, among others, power engineers, sanitary engineers, chemical engineers, industrial, petroleum, efficiency, results, accounting, human, stores, financial, and output engineers, and we have not nearly completed the list. Waterworks engineering is not a specialty in the sense that many of the foregoing are specialties. Perhaps no engineer, unless it be the municipal engineer, has a greater variety of problems presented to him than the waterworks engineer. He deals not only with hydraulic problems, pipelines, pumping engines and reservoirs, but he comes in contact with problems in steam, mechanical, electrical, and structural engineering—anything from a building or bridge to a foundation, retaining wall or chimney—and if he is a manager he needs to be familiar with accounting, and above all he must be something of a human engineer, for he must deal with the public which he serves, and not only with the individuals who make up that public, but their representatives who compose the municipal government. But while he must be familiar with various branches of engineering, if he is wise he will recognize his limitations and in the case of a difficult problem will call to his aid the specialist in that particular branch of engineering.

In this paper no attempt will be made to present the subject from a technical standpoint. The waterworks engineer, as a rule, deals with standard materials of standard sizes. Some of the formulæ which he uses may be styled "rule of thumb" and in many of those in which technical theory is applied to the materials used, a liberal factor of safety is provided. Such questions as the thickness of cast-iron pipe; the depth at which it should be laid; the sizes and best material for service lines; the valves, fire hydrants, meters, etc., best suited for a particular service, and the methods of setting them; the proper slope of an earthen reservoir embankment; the arrangement of inlet and outlet pipes to a reservoir, and many other questions, are to be decided by experience and judgment, and not by rule or formula.

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In the design of a waterworks system, the consulting or practising engineer usually has sufficient time to study the various phases of the problem in hand, but sometimes in construction it becomes necessary in an emergency to change plans quickly, to substitute one available material for another which is not at hand, and to do things which are not found in the books. The operating engineer faces many problems of this kind—instances where it is necessary to act immediately and to use such material as may be at hand.

As an illustration, in January, 1897, the author was called out of bed one night and told that "the stand-pipe has busted." The message came from the engineer at the pumping station, the stand-pipe being located within a few feet of the station. Getting to the station as quickly as possible, it was found that water was flying in all directions from the vicinity of the bottom of the stand-pipe. The stand-pipe was 15 feet in diameter and 140 feet high, built of wrought-iron plates, the bottom resting on a rubble masonry foundation, about eight feet above the ground. The stand-pipe was in place, and it was evident that the vertical sheets had not been damaged. Beyond that, it was impossible to tell what had happened, even at the expense of a ducking. The stand-pipe was emptied at once, and, upon getting into it, it was found that one of the bottom plates had broken apart for a length of five feet, and that the plate was cracked and corroded for a total length of more than nine feet. This had occurred immediately over the calking edge of the adjoining plate. Because of the height of the stand-pipe, its small diameter and the fact that the locality was subject to high winds, repairs had to be made as quickly as possible. There was no boiler shop within fifty miles.

The shop of the firm which erected the stand-pipe was over one hundred miles distant and by telephone it was learned that it would take some days to send men and get the measurements, prepare the necessary patch plate and put it in place. A mechanic was sent from the shop at once to take the measurements, but some plan of temporary repairs had to be devised by which the stand-pipe could be made tight enough to hold a sufficient amount of water to insure its safety in case of high wind. It was decided to cover the crack with a cement made as follows—fine cast-iron borings, 98 parts; flour of sulphur, one part; sal ammoniac, one part. The ingredients were thoroughly mixed dry, boiling water added and the resulting paste troweled over the crack to a thickness of an inch and a half or two inches, being spread out for a distance of three or four inches each side of the crack. The cement set quickly and the next day water was pumped into the stand-pipe and the patch proved to be water tight. The stand-pipe was then filled and was in use for some days before the mechanics arrived with the plate. Before the stand-pipe was emptied for placing the plate, it was guyed with cables. The sheets adjoining the crack were cut out and the patch plate put in place and secured with tap bolts. It was not until the plates had been cut out that the cause for the failure became evident. There was no joint of mortar nor cushion of sand, as there should have been, between the bottom of the stand-pipe and the top of the stone foundation. The manufacturer of the stand-pipe insisted that such a joint had been put in, but there was no evidence of it. The result was that the bottom sheets were supported above the stone of the foundation on the rivet heads. The stand-pipe had been in service about nine years. During the early part of this time it was customary to fill the stand-pipe, shut down the pump and wait until the water had been drawn down some thirty or forty feet. Later the stand-pipe was carried full during the day-time, with the pump running, but the pump was shut down two periods during the night. The changes in pressure, due to the repeated filling and partial emptying of the stand-pipe, caused a bending of the unsupported plate over the calking edge of the adjoining plate; resulting, in time, in the destruction of the paint, rusting, the fatigue of the metal and ultimately the fracture of the plate. While repairs were being made, a number of one-inch holes were drilled through the other bottom plates of the stand-pipe and several barrels of a sand and cement grout were poured into the spaces below the plates so as to avoid any future trouble of the kind. The plate which failed proved to be of excellent quality. The stand-pipe is still in service though it is 33 years since it was erected.

The operating engineer also has to handle reconstruction problems which involve not only the design and carrying out of plans and specifications, but he must keep the old plant going—maintain service—while the new one is being built. Frequently, construction of the new is not begun until the old has broken down or been outgrown, which makes matters materially worse.

An instance of this kind was the enlarging of the pump station of the Pennsylvania Water Company, at Nadine, on the Allegheny River about a mile and a half above Brilliant pumping station, in 1903-1904. The old pumping station consisted of an octagonal building about 60 feet across, over a pump pit 38 feet in diameter and about 40 feet deep. In this pit there were two 6,000,000-gallon, quadruple-expansion Nordberg pumping engines. It was necessary to construct a new pump pit large enough for two 10,000,000-gallon engines, and erect a new pumping station which should cover both pits, with sufficient room for a crane and auxiliary machinery. There was also involved, of course, the work of connecting suction and delivery pipes; the installation of two additional boilers, for which ample space existed in the boiler room; and the erection of a new and larger steam-pipe with connections. The available space for the new pumping station was limited. There was barely room, between the hill and the Allegheny Valley Railroad tracks, for the boiler house and the old pumping station, and the only available site for the new station was between the old station and the highway, which was an improved county road. The available space was further restricted by the fact that the 30-inch force main started up the hill from a large brick vault leaving barely space enough for the new pump pit and the necessary floor space between the vault and the old pump pit. The site of the pumping station was an old ravine

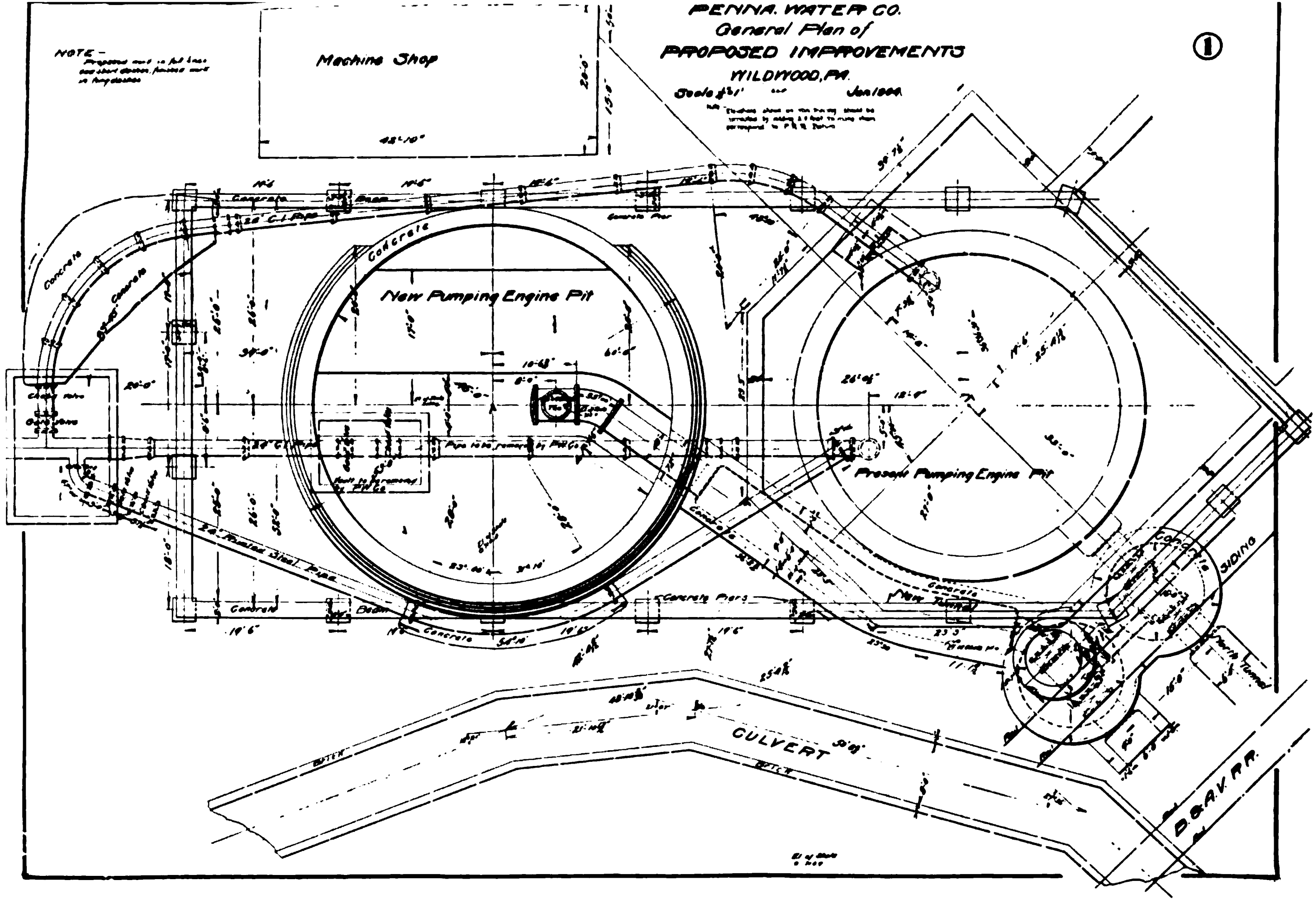

Fig. 1. Plan Showing New Pumping-Engine Pit, Tunnel, Piping, and Foundation for New Pumping Station.

which had been filled in with 12 to 20 feet of earth and cinders, the stream which flowed down the ravine having been diverted into a culvert, as shown on the plan. (See Fig. 1.)

Plans for a new circular pump pit 45 feet in diameter and 49 feet deep were prepared after the necessary space for the pumping engines had been determined, and then plans were begun for the pumping station building. Before the new pump pit could be built it was necessary to move the delivery line from each of the pumping engines then in service. Both were 24-inch, cast-iron pipe-lines. The one toward the hill was moved, the change in location being accomplished by the use of bends. The other was replaced by a riveted steel pipe. In this way the old pipe could be kept in service until the new one had been laid, and it was then only necessary to break out the old one and connect the new one in at each end. (See Fig. 2–4.)

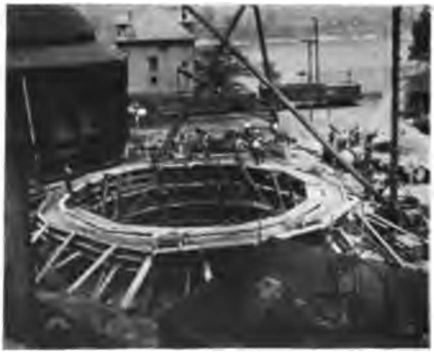

Fig. 2. View Looking North Showing Pumping-Engine Pit in Center and Old Pumping Station to Left.

Water was brought to the old pump pit through a six-foot tunnel connecting under the railroad tracks to the pipes from the filter cribs in the river. No provision had been made for a connection to this tunnel and it was necessary to cut into it and set in it a 48-inch tee and valves as shown on the plan. From the tee branch a new tunnel was run to the new pump pit and the suction pipe in that pump pit connected to the tunnel. At the time this work was done the demand for water exceeded the capacity

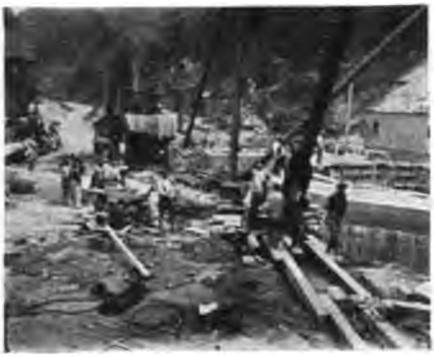

Fig. 3. View Looking Southeast up the County Road, Showing Restricted Space for Contractor's Plant and Material. Pumping Engine Pit Shown at Right.

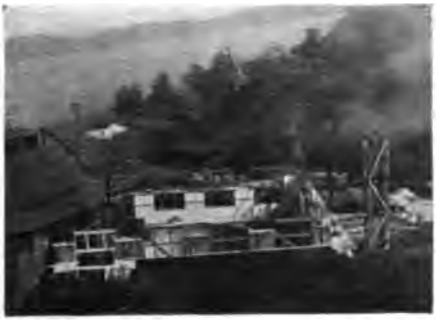

Fig. 4. View from Hill Looking North Showing Pumping-Station Walls Partly Erected. Old Pumping Station Shown at Left.

of one of the 6,000,000-gallon pumping engines, making it necessary to run one engine all of the time and both engines part of the time. The engines were pumping against a total head of more than 600 feet and, on account of low water in the river at times and the consequent difficulty of getting enough water from the filter cribs, the service had been hard on the engines and one of them in particular needed rather extensive overhauling and repairs, but it was impossible to shut it down long enough to make the repairs needed. It was frequently necessary to shut that engine down for temporary repairs and occasionally the other engine needed attention, which made it extremely difficult to keep a sufficient supply of water in the reservoir to permit shutting down both engines long enough to make the tunnel connection and to change the delivery pipes. To add to the difficulties of the problem, there were two floods in the Allegheny River during the progress of the work which not only stopped the work, but in each instance floating ice took the top off the intake manhole at the river and permitted raw water to get to the pumps, making it necessary to shut them down. At another time, a check in a check-valve on the delivery line of the engine toward the hill broke loose from its trunnion and smashed back through a large four-way special casting making it necessary to have a new casting made in Milwaukee and shipped by express.

As previously stated the pumping station is located on a fill in what was an old ravine. To have carried the walls of the building to bed-rock would have been expensive and would have increased the difficulty of relocating the delivery pipes. After study of this phase of the problem, it was decided to build piers of centers approximately 19.5 feet, and to carry the walls of the building on reinforced concrete beams between these piers. In construction it was found that at only one place did the pipe interfere with a pier and in that case the pier was carried on an arch supported on a pier on each side of the pipe.

The building of the new pump pit and the foundations for the pumping station was done by contract on a "cost plus" basis as there was no possible way of estimating closely what the work would cost. Sometimes when ready to make a connection or move a pipe, shortage of water made it impossible to shut down the station long enough to carry out the work, and it was necessary to wait until the reservoir had been replenished. The two floods interfered seriously, but ultimately the work was completed and the pumping station erected.

An unusual plan was adopted in purchasing the pumping engine. The conditions, especially the head to be pumped against, were so unusual that no trade pump or engine of ordinary design was suitable. On account of the increasing demand for water, it was decided that the new engine should have a capacity of 10,000,000 gallons a day. Because of the difference in elevation between high and low water in the river, it was necessary to place

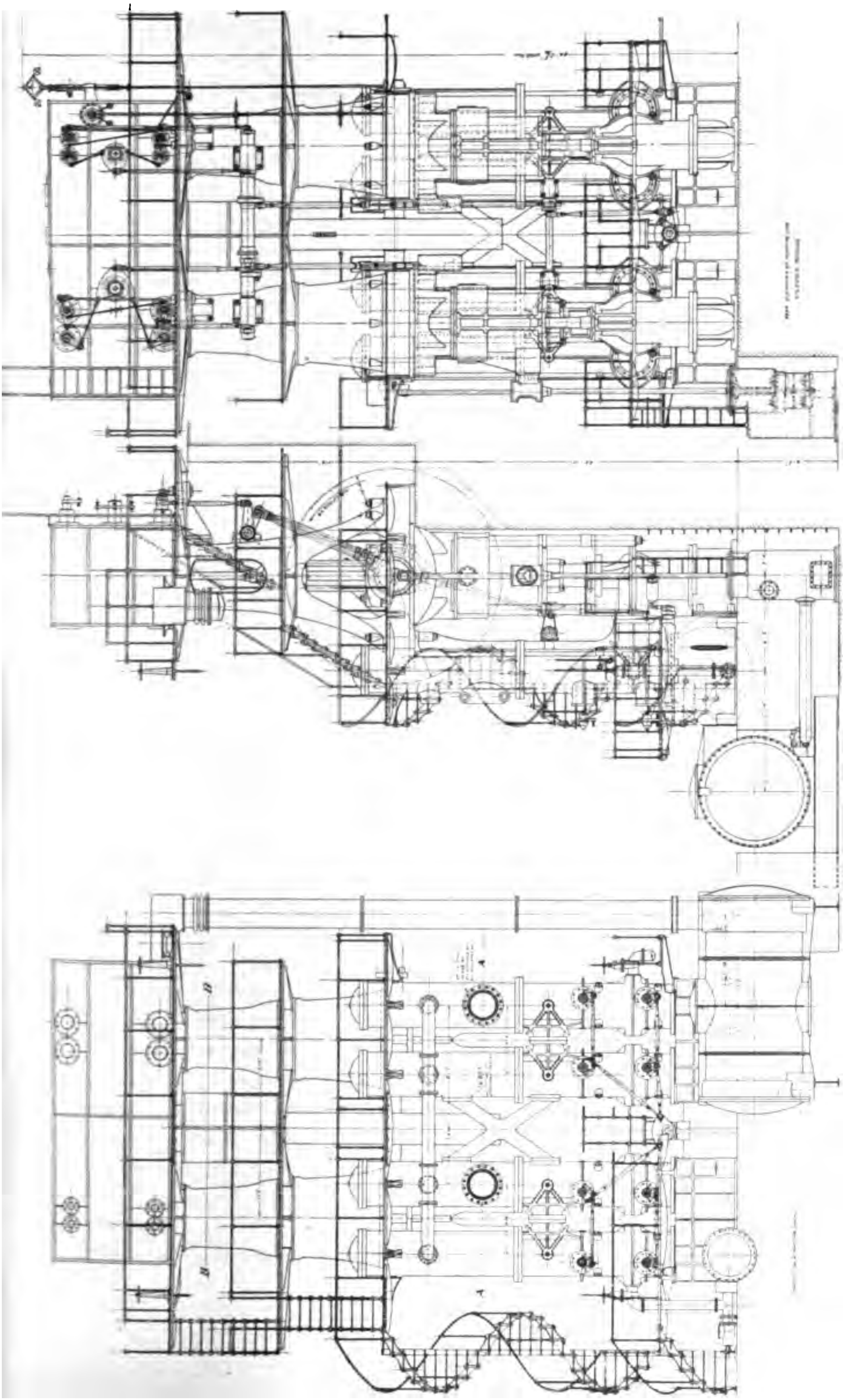

Fig. 5. Elevations of Allis-Chalmers-Riedler 10,000,000-Gallon Pumping Engine.

the engine in a pit, and the pit was made large enough for two engines. The space, therefore, was limited, and because of the desired capacity and the head to be pumped against, the engine would be larger in horse-power than any other engine at that time in waterworks service in the country, and probably in the world. Few if any consulting engineers in private practice had had experience with such conditions, and it was finally decided that the problem should be put up to some pumping-engine manufacturer who had had experience in design and manufacture of large pumping engines under high heads, and that the manufacturer should be asked to submit a design for a pumping engine of the desired capacity to work under the conditions, and should be required to give a guarantee covering design, material and workmanship, for a period of four years. No effort at competition was made, although prices submitted were carefully checked against current contract prices for pumping engines. After careful consideration the problem was submitted to the Allis-Chalmers Company, which had had large experience in the design and manufacture of engines to pump against high heads in mining and irrigation work. The final result was the submission of a plan for a 25 by 60-inch and 18¼ by 48-inch, vertical, compound, condensing, single-acting, pumping engine with Riedler mechanically operated water valves. Contract was made and the engine was erected and placed in operation in February, 1905. (See Fig. 5.)

This engine is unique in several respects. Being a single-acting engine, during the up-stroke the water flows by suction into the pump chamber and on the down stroke it is discharged against a head of over 600 feet. In order to equalize the work done on the up-stroke with that done on the down stroke, a piston is bolted to the top of the plunger, and the piston works into a cylinder secured to the under side of the bed-plate. On the up-stroke it compresses the air in that cylinder and the energy of the compressed air is given out on the down stroke. This obviates the necessity of conveying the energy through crank-pin and crank and shaft to the fly-wheel and back again to be used on the down stroke. The engine operates with a steam pressure of 175 pounds and runs at a speed of 65 r.p.m., or a piston speed of

520 feet per minute, and has repeatedly run to 72 and 73 r.p.m. At this high rate of speed, in spite of the fact that the engine is single acting and that it is nearly twice the capacity of the old double acting Nordberg engine, there is less water-hammer on the force main than was caused by the Nordberg engine.

With the ordinary pumping engine the manufacturer gives a one-year guarantee. The reason for asking for a four-year guarantee was that experience has shown in many cases that defects do not become manifest on a new pumping engine within a year. It was expected that the manufacturer would make a reasonable charge for the four-year guarantee. The experience showed that the guarantee was worth what it cost. Within about a year the valve decks proved to be too light. They were replaced with a heavier design; but, later, both the new valve decks and the valve-seats proved too light and, after examination by an expert called in by both parties, a still heavier design of valve deck was used and a slightly different design of valve-seat, both of which have proved satisfactory. Several pump barrels cracked and in every instance the crack was in exactly the same location. This resulted in a change of design and the new pump barrels have proved satisfactory. Both of these matters developed during the construction of a second pumping engine and changes were made in it accordingly.

The second pumping engine, practically a duplicate of the first one, was installed and started in 1907 and the two engines have been in regular service since that time. A duty test was made on the first engine by the late Charles Hague, a few months after it was started. The engine showed a duty of over 157,000,000 foot-pounds per thousand pounds of steam. The second engine, when tested, developed a duty of over 163,000,000 foot-pounds per thousand pounds of steam. These are record duties for compound pumping engines. The operation of the Riedler valves has been very satisfactory. They are much less troublesome and liable to get out of order than the ordinary rubber pump valve and the pump slip has been between two and three per cent.

After the installation of the Allis-Chalmers engines it was decided that it was inadvisable to attempt to repair one of the Nordberg engines and it was dismantled and removed from the plant. The second engine was used as a spare until the increased demand for water during the war made it evident that it should be replaced by a larger engine, and it was removed and the old pump pit, enlarged from its original diameter of 38 feet to a diameter of 45 feet, and a new Allis-Chalmers engine, practically a triplicate of the original, is now about ready to be started.

Incidentally the removal from the plant of the two Nordberg engines brings up the question of depreciation as related to the waterworks business. Up to the passage of the Pennsylvania Public Service Company Law in 1913, few, if any, water companies maintained an actual depreciation replacement fund. Some did not even set aside from their earnings anything to cover depreciation and those that did simply "wrote it off"—a mere bookkeeping entry. In such cases the money is not set aside; it remains in the business, goes into new plant, or possibly is paid out in dividends. The result is that, when it becomes necessary to replace an expensive unit or structure with a new one, the value of the unit or structure replaced must either come out of current earnings or else it must be new capital. The author has, in a previous paper,* illustrated the principle involved as follows:

> "Those of us who have owned automobiles for a few years have received practical and personal demonstration of the reality of depreciation. The machine that cost $2000 last year can be insured for only $1500 or less this year, and in from three to five years it must be replaced by a new one. It goes as part of the game; and when a new car is necessary we will write a check or mortgage the house and pay no more attention to it. But suppose by way of illustration, that a man in moderate circumstances invests his savings, and perhaps some money which he had to borrow, in an automobile and starts to operate a jitney or express route. Let us assume that he has no bad luck or accidents and that his earnings are sufficient to pay for gasoline, oil, tires and repairs and give him and his family a living. At the end of five years we will assume that the jitney has to be scrapped. Then unless the owner has been setting aside from his earnings year by year a proper amount of money as a depreciation fund, he finds himself worse off than when he started. He has nothing to represent the savings which he put into the machine and the money he borrowed. His "plant" has been wiped out. He has no fund to replace it,

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* "The Relation of Depreciation to Investment," Presented at the 23d. Annual Convention of the Pennsylvania Water Works Association, October 18, 1918.

> and if he is to continue in business he must find new capital. This is only an illustration, but the principle is as true and operates as surely in the case of the property of a water-works company or any other utility as it does in the illustration given. It is not only recognized in our Public Service Company Laws, but Public Service Companies have been severely penalized in the past because they have not provided depreciation or replacement funds."

The public service company laws of this and other states require that there be set aside year by year from the earnings of the utility an amount estimated to offset the reduction in value of the plant caused by depreciation. This money should be used to create a fund from which replacements to plant can be made, and only by so doing can the investment in plant be maintained intact.

In 1911 the 30-inch, cast-iron force main of the Pennsylvania Water Company was paralleled from the Nadine pumping station to the filter plant, located on Pucketa Road, Penn Township, by a 24-inch, lock-bar, steel force main. The steel plates of this main were ⅝ inch in thickness at the lower end and 3/16 inch in thickness at the upper end. The pipes were coated by dipping in a bath of mineral rubber, and the material and workmanship of the pipe were of the best. After being in service about seven years, occasional leaks began to occur in the portion of the line near the filter plant. These leaks were immediately adjoining the lock bar and appeared to be due to a rusting through and tearing apart of the sheet. The breaks ranged in length from two or three inches to a maximum of 18 or 20 inches and all occurred within the upper 500 feet of the main. Careful study of the conditions led to the conclusion that the breaks were not due to defective steel sheets, but were probably caused by the fact that the sheet, especially in a pipe of small diameter may not be gripped by the lock bar in a true circle. Where the pressure on the pipe is sufficient to force the sheet into a circular form, and hold it in a circle, while there may be some unusual stress put upon the material at the point where it is gripped by the lock bar, no damage is done. But in the upper portions of the force main, water-hammer—that is, the fluctuation in pressure due to the operation of the pump—is sufficient at its maximum to spring

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the sheet to a circular form, but, as the pressure in the pipe decreases to the minimum, the elasticity of the sheet causes it to spring back wholly or partially to its original form. This continued action many times a minute doubtless caused the failure of the sheets. About 400 feet of the lock-bar pipe was replaced with cast-iron. Probably steel pipe with thicker sheets would have served, but on account of the necessity of doing the work quickly so as to keep the main out of service as short a time as possible, and also to interfere as little as possible with traffic on the country road along which the pipe was laid, it was decided to use cast-iron. The pipe which was taken up was found to be in excellent condition except in the few places where damaged along the lock bar. The mineral rubber coating adhered to and covered the pipe perfectly with no evidence of rust on the sheets.

The Pennsylvania Water Company had an unusual experience many years ago with a 42-inch, cast-iron supply main. It was laid in 1899 and conveyed water between two reservoirs, and thus was comparatively free from water hammer. For some reason the pipe used was lighter than standard weight. The author has been unable to find the formula which was used in determining its thickness and weight. By 1902 there had been several breaks in this pipe and its condition was such that it was deemed no longer safe to use it except that part of it which was upon high ground and under not more than 50 pounds pressure per square inch. The rest of it was taken up and replaced with 36-inch cast-iron pipe. At the time that the 42-inch pipe was laid, an approximately equal amount of 30-inch pipe was laid for the same service and under the same conditions, being an extension of the 42-inch pipe after connections had been made to the distribution system of Wilkinsburg and adjoining territory. The thickness of metal of the two pipes was calculated by the same formula. The pipe was bought at the same time from the same foundry and yet the 42-inch pipe failed and the 30-inch pipe is still in service after more than 20 years. The reason for this is probably that in cast-iron pipe, up to 30 inches in diameter, no consideration need be given to the external earth pressure, but above 30 inches in diameter it is necessary to increase the thickness of the cast-iron pipe to care for earth pressure.

There have been two breaks in that portion of the 42-inch line which was left in service. These occurred under normal working pressure although the pipe had been tested to 50 pounds in excess of the working pressure before it was put into service. Both of these breaks were found to be caused by the pipe resting upon a stone or rock, and two breaks have occurred in the 30-inch line from the same cause. This matter was looked after with scrupulous care in the laying of the 36-inch pipe and there has been no break in that pipe-line since it was laid. This experience calls attention to the provision not infrequently seen in specifications for large pipe-lines, especially in soft ground, to the effect that the pipe shall be laid on one or two wooden blocks or saddles per length. Concentrating the load at one point is dangerous, and while the blocking may be made to fit the pipe so that the concentration would be less than in the case of a pipe bearing upon a rock, still it is wrong in principle. It is better to give the pipe a uniform bearing and it can be done by proper care in bottoming the ditch and backfilling.

Cast-iron pipe, especially the small sizes, should be thoroughly bedded when laid. This is a matter which sometimes is not given the attention it deserves. Many of the breaks which occur in newly laid pipe of adequate thickness doubtless occur from uneven settlement due to improper bedding of the pipe when laid. After pipe has been laid long enough to become thoroughly bedded, a considerably higher pressure may be put upon it than would be considered safe for the weight of the pipe used. The author knew of a case where four-, six-, and eight-inch pipe as light as 20, 30, and 40 pounds per foot, respectively, were laid in a valley where the normal pressure did not exceed 90 pounds per square inch. Some years later, as the population increased and building extended onto the hills adjoining the valley, it was necessary to build a reservoir at an elevation which increased the pressure on these pipes to from 150 to 165 pounds per square inch, and although some breaks were expected, very few occurred. Had new pipes been laid for such pressures the weights would have been 21, 33, and 47 pounds, respectively.

In these days of heavy automobile trucks with large skid chains hammering over the pavements of our municipalities, the question of the proper depth to which pipe should be laid, as well as the thorough bedding of the pipe, must receive careful consideration. Cast-iron valve manhole covers which stood the traffic of the past are being broken by the trucks of to-day. The question of adequate depth to secure against freezing of service pipes was forcibly brought home to waterworks managers by the winter of 1917-1918, when frost in both paved and unpaved streets in this district went down to a depth of four to four and a half feet. Many service lines, both in the city and in the adjoining boroughs, which had never before been affected by frost, were frozen during that winter. In fact, trouble from frost was experienced generally throughout the northern and eastern portions of the country. In many cases even mains were frozen.

In the last fifty years there has probably been less improvement in the manufacture of cast-iron pipe than in any other material or supply used in waterworks construction, and this in spite of the efforts of the leading waterworks men of the country through the American, New England and other waterworks associations. Twenty-five years ago comparatively few purchasers of cast-iron pipe had it inspected at the foundry. It was given the usual hammer test under 300 pounds pressure, by the manufacturer. It was "inspected" upon delivery as it was unloaded from the car, and it was again tested by hammering when lifted by the derrick and ready to lower into the ditch, the "ring" of the pipe under the hammer being depended upon to show whether or not the pipe was cracked. These methods did not detect sand holes, cold-shuts, nor cores out of center, and gradually a considerable number of men and firms have taken up the testing of cast-iron pipe. This is done at the foundry before the pipe is coated and it is generally recognized to-day that no municipality or company is so poor that it cannot afford to have its pipe tested, and none is so rich that it can afford not to have it tested. Those who do not have their pipe tested generally get the culls.

There has been a strong effort on foot for a few years past to get the manufacturer to cast each pipe of a given nominal size, of the same outside diameter, the thickness of the metal to be varied by changing the diameter of the core. This plan has numerous advantages, such as the uniform size of bell and spigot, which would do away with the difficulty of entering a spigot of a heavier pipe into a bell of a lighter one, but the manufacturers so far have steadily refused to change their methods. The National Iron Corporation, of Toronto, Canada, is now putting on the market pipe made by the DeLavaud centrifugal process. By this method, the molten iron is poured into a horizontal mold revolving at high speed. The centrifugal force throws the molten metal against the mold in a uniform thickness. The metal of pipe made in this manner is said to have a tensile strength of from 35,000 to 39,000 pounds per square inch, which is practically double the tensile strength of the metal of ordinary cast-iron pipe. If this method is successful it is probable that it will have a very material effect upon the cast-iron pipe industry.

One of the important innovations in the laying of cast-iron pipe within recent years has been the use of sulphur compounds instead of lead for making joints. Lead requires calking while the sulphur compounds do not, and thus they obviate the employment of a class of labor which is always troublesome and whose work requires watching and inspection. The sulphur compounds are harder and do not squeeze out of a joint as does lead. They not only save the cost of calking, but the first cost of the material is less than lead and there is the additional saving in the digging of the large bell holes required to calk a lead joint, and the maintenance of bell holes and ditch while the joint is being calked. At present prices the saving is from 50 to 75 per cent. of the cost of lead joints.

The question of the best material for service lines is one which must be solved for each locality. There is no one material which is satisfactory everywhere. In some places soil conditions make it impossible to use iron or steel pipes, either galvanized or black, and in others they fill all requirements. Some water will rust iron pipes, and thus necessitates the use of lead, tin-lined pipes or cement-lined pipes, which are used to a considerable extent in New England. A soft water or a water containing considerable carbonic acid gas cannot safely be conveyed through a lead pipe as it is liable to dissolve lead from the pipe and cause lead poisoning. In such cases a tin-lined or cement-lined pipe should be used. A serious trouble with lead pipes has been the plumbers' wiped joint. The failure of these joints under ground is a constant source of leakage and waste. There are now on the market patent couplings so that the use of the wiped joint is no longer necessary. These couplings seem to be coming into favor rapidly.

We have recently heard a great deal regarding earth slips. The topography and geology of this district are such as to cause many slips on our side-hills. The immediate cause is sometimes difficult to ascertain, but, once started, a slip is exceedingly difficult if not impossible to control. An interesting case of this kind occurred some 15 or 18 years ago to one of the banks of the Pennsylvania Water Company's No. 2 Reservoir on the hill in Braddock Township immediately back of—that is northeast of—the borough of North Braddock. This reservoir was constructed in the late nineties and controlled the water-supply of the Turtle Creek Valley. The south bank of this reservoir was approximately 30 feet in height. It was an earth bank with an inside slope of 2 to 1 and an outside slope of 1.5 to 1, the inside slope being lined with concrete for its entire height, and the outside slope sodded. The top of the embankment had a width of 11 feet. There had been some slight evidences of a settlement in this bank, but none of a slip, and it was thought that the settlement was caused by a consolidation of the material due to its height. There was no evidence of leakage through the bank. One night in the early spring of 1903, there was a sudden settlement

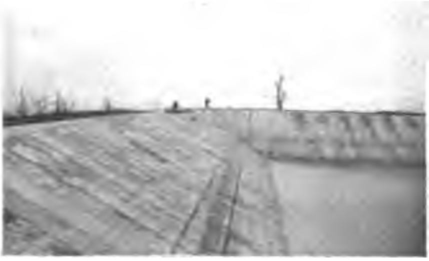

Fig. 6. Beginning of Settlement of Top of Reservoir Embankment at Western End of South Embankment.

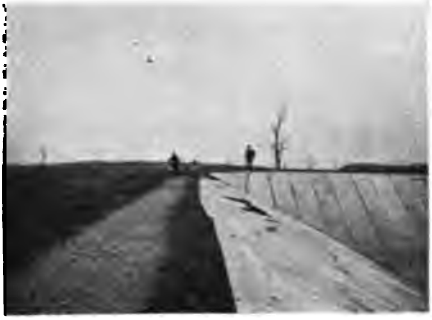

Fig. 7. Close-Up View Showing Beginning of Settlement of Top of Reservoir Embankment.

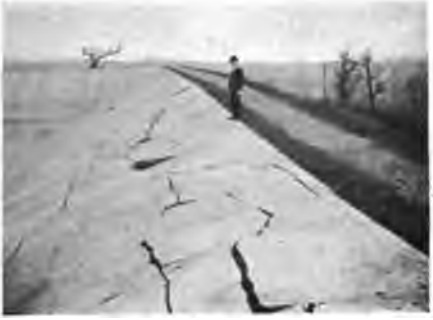

Fig. 8. Breaking of Concrete Reservoir Lining by Settlement of Embankment.

in this bank to the amount of more than one foot. (See Fig. 6-8.) This was noticed by the watchman and immediately the water was drawn from the reservoir. The settlement of the bank continued as is shown by the illustrations, and there was evidence of the slipping of the bank at its toe immediately above the road. (See Fig. 9-12.) A 16-inch, cast-iron pipe by-pass was laid around the reservoir so that water could be supplied around it while repairs were in progress. The center of the settlement and slip seemed to be adjacent to and over the 48-inch outlet pipe. The embankment was removed and this pipe uncovered. There was some evidence of slight leakage and it was taken up and relaid. The embankment was then re-

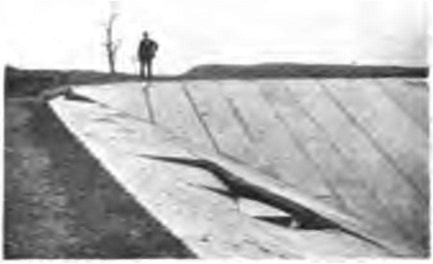

Fig. 9. Breaking of Concrete Reservoir Lining by Settlement of Embankment.

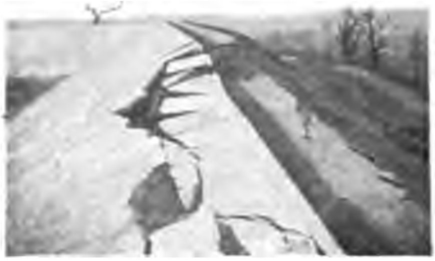

Fig. 10. Result of Continued Settlement of Reservoir Embankment.

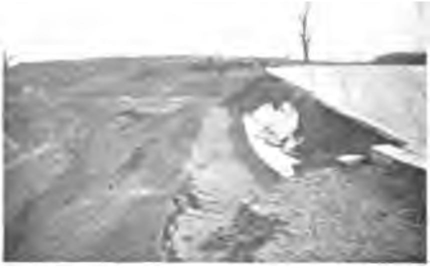

Fig. 11. Result of Continued Settlement of Reservoir Embankment.

built and in order to get a somewhat better foundation the centerline of the new portion of the embankment was shifted about fifty feet into the reservoir at its westerly end, making an angle in the southerly embankment of the reservoir which had formerly been straight. Great care was taken to join the new portion of the embankment with the old. When the repairs had been completed and the reservoir put into service there was, after some weeks, evidence of settlement and slip of the new portion of the reservoir bank. It was then determined to drill into the rock under the toe of the embankment and set 20-foot lengths of eight-inch well casing in concrete, the casing being filled with concrete, also. The casing was spaced 2.5 feet between centers. After some months, still further settlement and slip were evident, and a shaft was sunk, near the center of the portion of the embankment which appeared to be moving, until rock was encountered. Then the cause of the slip became evident. The surface of the shale rock of the hill was covered with a layer of heavy clay, less than one inch thick, on which the embankment was sliding. From the shaft, tunnels were run in all directions through the extent of the slip and this layer of clay removed, the surface of the rock made rough and the tunnels backfilled and thoroughly tamped. The embankment had only settled a few inches. It was again filled to grade, and there has been no further settlement or slip.

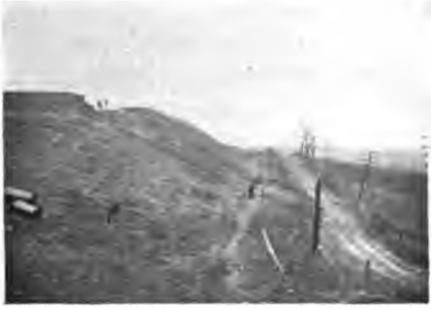

Fig. 12. Settlement and Slip of Reservoir Embankment as Seen from a Point to the West of South Embankment. (Showing how Embankment Has Pushed out upon Road.)

The plans for this reservoir showed that after removal of the top soil the earth upon which the embankment was placed was excavated in a series of steps and the embankment then constructed. The slope of the original surface was about 1 to 3. The existence of the layer of clay on the rock was not revealed by the test pits which were dug, nor in the excavation for the reservoir during its construction.

The author will not weary you with any discussion of pumping station operation problems. Those who are connected with the power-plants of Pittsburgh's great industries have presented to them greater and more varied problems than occur in a pumping station. Neither shall we attempt to discuss the question of water purification, for to do so would extend this paper very considerably and tax your patience beyond the limit.

In closing, your attention is called to the most serious problem which confronts private water companies in Pennsylvania to-day, but which is not an engineering problem. It is the position in which water companies, and in fact all public utilities, are placed by the operation and enforcement of the Public Service Company Law, and is more or less true of all the states in which similar laws are in force. Before the Public Service Company Law was passed in 1913, water companies were, in effect "free traders." The rate of return upon capital was practically not limited by statute. Rate cases had not become the vogue and decisions of the state supreme court had settled the questions of exclusive rights, municipal competition, etc., upon a fair and just basis. Five per cent. water bonds were considered gilt-edged securities. When the Public Service Company Law was enacted it was assumed by the public that many utility rates would be reduced. This expectation has not been realized. The claim of over-capitalization of the utilities has not been generally substantiated. In a few cases rates have been reduced. In most cases, however, especially those of water companies, while the reduction, if any, has been slight, there has been a general readjustment of rates with the result that the rates for municipal service, such as fire protection, which had been less than the cost of the service, have been materially increased with a corresponding reduction of domestic and industrial rates. Free service has also been abolished. In addition, the tremendous increase in expenses of the utility companies, due to the war, has resulted in many increases in rates and to-day we find a state-wide effort being made to secure the repeal of the Public Service Company Law, or its amendment so as to take away some of the powers of the Commission. The utilities find themselves, under the Commission, subject to the attack of every dissatisfied consumer, obliged to assume burdens which had not previously been borne and which had not been included in costs on which rates were based, and—which makes the situation most difficult of all—restricted to a return of seven per cent. on the investment. Before the war there was abundant testimony before the Commission that a seven per cent. return was inadequate to attract new capital. The Commission, however, doubtless faced the fact that to allow a higher return would have resulted in an increase in rates in most of the cases which were before it. Increased operating expenses have compelled many increases in rates during and since the war, but the Commission still adheres to a seven per cent. return as being a reasonable return on capital invested in waterworks enterprises. Obviously, with conservative investments offering a return of from seven to nine per cent., capital is not looking for investment in a waterworks enterprise under existing conditions. The price of money (interest) has increased as well as other prices and this fact must be recognized if the money needed for extensions is to be secured.

In what has been said there is no wish to criticize the Commission. There is no more conscientious, hard-working body of men in Harrisburg than the Public Service Commission. Its work was pioneer in character and has been made difficult by repeated changes in personnel. It has taken time for the clearing up by the courts of certain disputed questions in the provisions of the Public Service Company Law. The Commission has had to do its work with inadequate appropriations. It has been the target for the abuse of petty politicians and some newspapers—disappointed because rates were not greatly reduced. The war and its consequences have added much to the burdens of the Commission and are responsible for many of the difficulties of the present situation. The public applauds the application of the Commission's power to the reduction of a rate which is unreasonably high but resents the correction, by the same power of a rate which is unreasonably low, especially if the municipality is benefiting by the low rate—forgetting that a rate which is too low is just as discriminatory as one that is too high, since, if the utility is to receive a reasonable return, low priced service to one must mean high priced service to some one else. The difficulty arises from the erroneous idea that the sancity and inviolability of a contract are involved, whereas the courts have ruled repeatedly that it is a question of service—good service—at a reasonable rate, and that anything else is discrimination and hence unlawful. Under the old idea, long-term contracts were sometimes made with favored consumers at low rates; or a municipality by threat of competition, or otherwise, would force a low rate for municipal service, or even free service. To-day the commissions and courts are standing for the application of the square deal to utility rates—good service, at reasonable rates to be paid by all receiving service. Engineers can be of great service to the public and to the utilities which serve the public, as well as to the Public Service Commission, by advocating this doctrine and explaining it, as apportunity offers.

DISCUSSION

MR. GEORGE H. DANFORTH, *President*:* I believe the retiring President's address is not considered a subject for discussion, but I think I know Mr. Hawley well enough to say that if any one has any questions to ask he will be pleased to answer them.

MR. G. E. FLANAGAN:† In regard to the question of making the cast-iron pipe heavier in weight by reducing the interior diameter of it, I would like to ask what is the manufacturers' objection to that proceeding? Why are they opposed to what seems to be the most natural way to increase thickness, keeping it as uniform in other respects and still getting an increase in weight by what would seem to be the easiest way; that is, by making the outside always the same diameter for a given size, and deceasing the size of the core. All lap-welded and butt-welded wrought pipe, iron or steel, is of uniform outside diameter for any given size, so that the same flanges and fittings may be used for various weights of pipe, and the weights known as extra strong and double extra strong are formed by reducing the inside diameter.

MR. W. C. HAWLEY: The proposition was to vary the weights by changing the diameter of the core, the outside diameter of the pipe to be kept uniform. The manufacturers objected because they have their molds and everything ready and in use, and to make the necessary changes would mean considerable expense to them. They admit the desirability of the changes but refuse to make them, because of the expense.

These pipe-foundry men are funny fellows to deal with. I had an interesting experience some years ago. We were getting some 36-inch pipe. It was heavy pipe and the foundry was very busy. My inspector reported that he was having a great deal of trouble to get pipe to conform to the specifications, so I went to the foundry to see what the trouble was. I met one of the head men of the foundry and he took me out to the shop where they were making a large special casting, and, while we were watching the work, I saw them pick up with a crane a bundle of six-inch cast-iron pipes, red hot—so hot that the man who was handling them had to use a long pole. I expressed my surprise at their taking the pipe out of the flasks so hot, because it is contrary to good practice. He assured me the pipes were small and light, but if they were large and heavy they would not do such a thing. I went in to one of the other foundries and saw them pouring some of our 36-inch pipe, and then I went to lunch. About an hour later, I came back and they were already taking our big pipe out of the flasks, red hot—so hot the men could not get near them. Not only that, but they up ended the flask and opened it and let the pipe fall. This, of course, made the pipe out of round—a feature with which we had been having a good deal of trouble. I went down to the office and objected and I was assured by the manager that those pipes were very thick and heavy and it really did not make any difference whether they took them out of the flask when they were red hot or not. If they were thin and light of course they would not think of doing so!

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†Mechanical Engineer, Heyl & Patterson, Inc., Pittsburgh.

Mr. G. E. Flanagan: Would it be any easier to increase the outside diameter and leave the inside diameter as it is?

Mr. W. C. Hawley: That is what they are doing now. To change would, of course, mean the making of a new set of molds and making the cores over so as to vary the thickness of the pipe. The waterworks associations, represented by some of the best engineers and waterworks men in the country, and men thoroughly familiar with foundry practice, have been trying for ten or twelve years to get the foundrymen to make these changes, but they have not done it and there does not seem to be very much prospect that it will be done in the near future, at least.

Mr. G. E. Flanagan: I might say that the educational value of a paper like this is in keeping us awake by bringing us in touch with other people's troubles; and, through listening to this paper to-night, those who have work to do, even though not similar in character, may be encouraged to look ahead a little further than they would if they had not heard the paper.

In that connection, a little incident occurred under my observation that might be of interest in a similar way. During the year we had a great flood in the Monongahela. I was engaged in putting up a power house on the South Side and, when we knew the flood was coming, we began to make preparations for it. The basement of the large building was below the water level even in normal times, and a large concrete well that was to serve as intake for water we were going to pump from the river for condensing purposes was roofed over with concrete, because we knew that it would be under water in flood stage. It had two 30-inch manhole covers on the top—water tight, so that the water could come over the well and do no damage. The well was connected with the power house below water level. When the flood was coming, those manhole covers were put in place and all other openings by which water could get from the river into the basement were sealed tight—that is, all but one. That was insignificant and probably less than four inches in diameter, but it was overlooked and the water got in from the river through that four-inch opening, filling up this well and trapping the air in the upper portion of it. When the air pressure reached a certain stage it blew off the manhole covers and that let the river into the basement. Fortunately, there was little or no machinery installed and there was little damage other than the dirt and silt that came in, but the incident illustrates the trouble the man in the field may have from some little oversight.

On the other hand, we had a piece of good fortune. We took the highest recorded stage the water had ever reached and, to be on the safe side, we put the engine-room floor two feet above the highest water we expected ever to have, and when the flood came it was within one inch of the engine-room floor.

MR. GEORGE H. DANFORTH, *President*: Mr. Flanagan's remarks on the other fellow's troubles bring up a subject that is always interesting. Some years ago there was an informal club among the building fraternity of Pittsburgh that used to take lunch together once a week; and, as a matter of interest, they started to tell of the troubles of the various trades, and you may be surprised to know that the funniest performance of all was when a wholesale lumberman told his troubles. You always find interesting tales, and sometimes in very unexpected places.

Jared Sparks

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VOL. 37 MAY 1921 No. 4

PROCEEDINGS

OF THE

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

AERIAL PHOTOGRAPHY AS APPLIED TO SURVEYING - - *J. B. Mandeville*
CONTINUOUS ROLLING-MILLS - - - - *John W. Sheperdson*

PITTSBURGH
UNION ARCADE BUILDING

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AERIAL PHOTOGRAPHY AS APPLIED TO SURVEYING

By J. B. MANDEVILLE*

The subject of maps is of great interest to most of us and the cost of essential maps is of vital importance. The time necessary to make maps so they are available when needed is another consideration. Sometimes the time saved by having reliable maps is of more importance than the cost. The accuracy required in any map affects both the cost and the time required to make it, for the greater the accuracy the higher the cost. This cost may easily exceed any possible value the map would have when completed, and, in many cases, it is very difficult to decide just where this dividing line between accuracy and cost should be drawn.

This brings us to a consideration of the possibilities which lie in the use of the aerial camera and the aeroplane. The method is not well understood and many extravagant claims have been made regarding aerial maps or mosaics. Many people have the erroneous idea that a mosaic is an accurate and complete substitute for the topographic map.

It cannot serve this purpose except over a flat or nearly flat terrain. Over any country which has much relief, the displacement caused by the hills and valleys will affect measured distances to a greater or less extent.

In the *Military Engineer*†, a paper on the tri-lens camera is discussed by W. E. Parker, Chief, Division of Hydography and Topography, United States Coast and Geodetic Survey. Mr. Parker was formerly a captain of engineers. Mr. Parker says in part that many persons, including some engineers, seem to think that from aerial photographs a topographic map may be made without any ground control whatever, and that such maps would be suitable for all purposes. This is not so. Mr. Parker thinks that the greatest use aerial maps will have is in correcting and bringing up to date maps which have been made some years, and using the control of these maps for correcting and fitting in the photographs.

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*Engineer, T. W. Phillips Oil & Gas Co., Butler, Pa.
†V. 12, pp. 362-363.

My own idea at first was this: Would it not be worth considerable to have a picture of the territory in which we were working, this picture showing all the physical features of the country. In planning our work it would be of great value, showing, as it would, all features of the country. An example of the manner in which typical features may be shown is given in Fig. 1, which reproduces a view taken near Dayton, Ohio, at an elevation of about 12,000 feet.

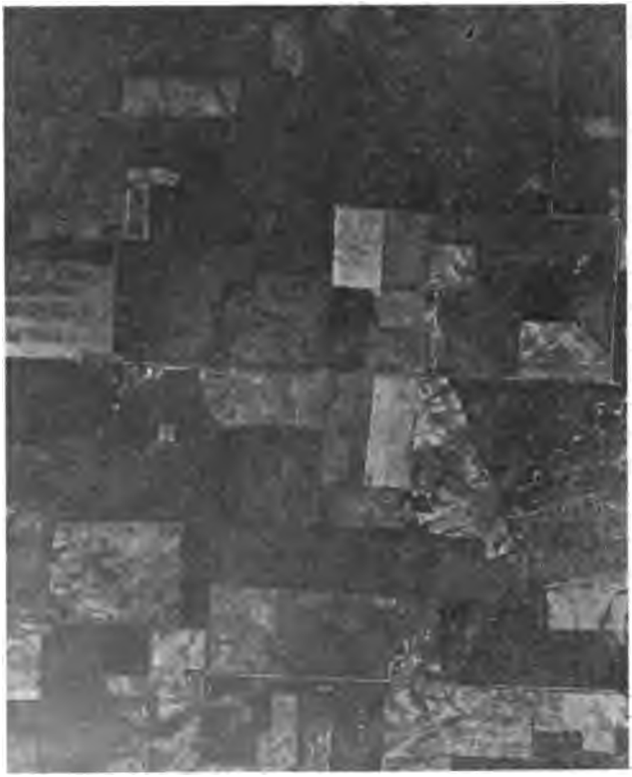

Fig. 1. Section of Terrain Near Dayton, Ohio. U. S. Air Service.

The next idea was how to adapt this method to making maps. A careful study of the subject convinced me that maps for oil and gas purposes could in this manner be made more cheaply and rapidly than they are now made, and I still hold that idea.

For a beginning I might describe just what kinds of maps we need in the oil and gas business. Oil and gas maps are used to locate routes for pipe-lines and to show these lines when completed; to locate new wells and to show their position with reference to others; to show location and shape of leases. In this connection I might add that we color leases, using one color for reserve and another color for operated leases. From this it will be seen that features of the country which should be shown on the map are, roads, railroads, streams, property lines, farm acreage, and farm ownership. The United States Geological Survey maps do not show property lines, but show contours.

In making oil and gas maps the following method is usually followed. First a stadia and compass survey is made of all the roads and railroads, and often some of the larger streams in the area are traversed. When making these surveys, measurements are taken to all property lines which touch the survey line, together with a compass bearing of the line. A stadia survey of this sort does not consider any vertical angles. No plumb-bob is used, the instrument being set up over a temporary mark made on the ground, and the instrument constant is neglected. In this manner circuits are run in such a way that they close on themselves or on some other circuit of the survey, so a check can be maintained upon the general accuracy of the work. Ordinarily these notes are plotted by the use of a straight-edge and protractor. The oil and gas maps are plotted to a scale of 80 rods or 1320 feet to an inch. In surveying and plotting circuits by this method any circuit that includes five miles or more must close with an error of less than 150 feet. If the error is much more than this the circuit must be re-run.

In the above method the survey will close and yet not be an exact survey of the ground covered. It will be somewhat longer than the actual circuit, due to the neglect of the vertical angles, the stadia constant, etc. This point should be remembered, as it will be mentioned later in conjunction with the accuracy of aerial photographs. In aerial photography the class of aeroplane to be used is immaterial except in a few points. The plane should have a fairly large fuselage to give room for mounting the camera. It should be able to get to the desired height without great delay.

Any plane which will climb to 10,000 feet in about thirty minutes will answer this. It should have a cruising speed of from 70 to 80 miles per hour, and a cruising radius of from three to five hours. It should not be of too heavy a type, as a heavy plane needs an extra good landing field from which to operate. A Curtiss plane equipped with a 150-horse-power motor would be a first-rate machine to carry on work of this kind. Developments come rapidly in aeroplane work. Since the writing of this paper was started, Glen L. Martin, of Cleveland, has brought out a two-engine plane which it is said is very light and convenient. I have not been able to get any exact information as yet concerning this plane, so cannot go into details regarding it. However, any plan having two engines is very much safer than a plane with one, and as the previous two-engined types have been very large and heavy, the one above mentioned seems to be great step forward. The United States government is using with great success a De Haviland 4 with a Liberty motor.

Another ship that might be used is the pony "blimp," manufactured by the Goodyear Tire & Rubber Company. This is a small dirigible balloon, 92 feet long and having a carrying capacity of three persons. A "blimp," like an airplane, has advantages and disadvantages. Its advantages would be its stability and freedom from vibration. It is not subject to forced landings and it can stop and hover over any point desired. Its disadvantage is high first cost ($20,000) and higher expense in operating, as a "blimp" of this size needs from 5 to 10 men for a landing crew. The gas for the bag is expensive and often hard to obtain. "Blimps' of this size have a ceiling of 6000 feet. They would drift badly in a side wind, and are hard to hold at an exact height, due to changes in the gas on account of heat and cold. A moving picture was taken with one of them last summer with fine results. The problem in this picture was to get a view of troops which were scattered over an area of two or three square miles. By the use of the "blimp" the picture was obtained in fine shape. I do not know under what name this picture will be released, but they are going to advertise the way it was taken, so it can be identified from that when it comes out.

The best camera for map work, or mosaic work as it is called, is the Eastman K1 aerial camera. This is an automatic film camera taking a picture about seven by nine inches. The type now on the market is operated by a wind-motor attached to the side of the fuselage. It is possible to operate by a storage battery and a small motor. This is a much better arrangement than the wind-motor, as a much closer control of the exposure can be obtained. The one trouble with the wind-motor is its possible irregularity due to its position in the blast from the propellor.

A tri-lens camera has also been built to overcome the difficulty of obtaining a lens which has enough speed and at the same time a wide angle of view. The tri-lens camera accomplishes this and is really three cameras working in unison. The shutters on all these lenses are operated so that they open and close at exactly the same instant. The time of exposure must be as short as possible so that a sharp picture may be obtained. This necessity is the result of several causes, chief of which are the vibration of the engine and the roll of the plane. The consequences of such vibration will be noticed in almost all of my slides. This vibration is the cause of the fuzzy appearance of the lines when they are enlarged on the screen. The film is wound off by hand and is five inches wide and about 400 feet long. Each picture is five inches wide and six inches long. The time interval between exposures varies roughly from 15 seconds to one minute. Very recently the cameras have been much improved by the introduction of a level bubble which shows how much the camera was out of level at the instant the exposure was made. The bubble is photographed on each picture so that a permanent record is kept showing the tilt of each photograph. It is possible also, to include a picture of the clock, thereby giving a record of the time the photograph was taken.

The so-called transforming camera brings the outside picture of the tri-lens camera into the same plane and to the same scale as the center photograph. The tri-lens camera will cover from three to nine square miles in a single picture, the area covered varying with the elevation of the camera, thus from 50 to 100 square miles may be photographed in one hour. The tri-lens camera will give much better results over marsh lands or an open country of very low relief. This is because the oblique pictures, when transformed so they are in the same plane as the center picture, still show all structures, hills, etc., in elevation instead of in plan. In other words, you are looking at the side of a house or a hill instead of directly down upon it. Another disadvantage is that unless the visibility is first-class, the haze will interfere with the side or oblique pictures much more than it will with the central one. The transformation also to some extent spoils the sharpness of the picture.

A control panel which is a part of the camera allows the speed of the exposure to be varied. This speed should depend on the speed of the plane and the amount of overlap required on each picture. The Eastman K1 camera is equipped with either a 12-inch or 20-inch lens. The 12-inch lens is the one to use on the class of work under discussion at elevations under 10,000 feet. The 12-inch lens at 5000 feet will cover about 2916 by 3750 feet without considering the question of overlap. This will give a scale on the mosaic of about 400 feet to one inch. For mapping purposes an elevation of 8000 feet seems about right. At this height the ground detail would be good enough to show everything necessary to be seen. It would give a terrain area covered of about 4700 by 5800 feet, or, allowing for the necessary overlap, a terrain area of about 3500 by 4350 feet. At 8000 feet the map scale would be about 500 feet to the inch. This scale is somewhat larger than I desire for my personal work, but if you go higher with the idea of making the scale smaller, you begin to lose some of the essential details.

In this connection it might be well to consider at what height to fly to make an aerial survey of an existing railroad, this aerial map to be used in conjunction with the usual alignment or right-of-way maps. It seems to me that either 2000 feet or 3000 feet would be about right. At 2000 feet you would get about 722 feet on each side of the center line; and, at 3000 feet, about 1080 feet on each side, which should be sufficient. The scale at an elevation of 2000 feet would be approximately 175 feet to the inch, and at 3000 feet elevation it would be 250 feet to the inch. The detail which would be obtained at 3000 feet would be very precise, showing the ties, if these were above the ballast, all the telegraph poles, switches, etc. Some of our own photographs taken at 4000 feet, with a camera much inferior to the K1, enabled one to see most of these details. It is well to remember that the higher the elevation at which an aeroplane flies, the safer it is, especially in a country where safe landing fields are scarce. The distance which could be covered in a day in such a survey would probably be from 50 to 200 miles. Probably 100 miles a day would be a fair estimate.

The method of mounting the camera in the aeroplane should receive careful consideration. The best apparent method is to mount it on gimbals with small spirit-levels set at right angles, so that it can be kept level if the plane tips a trifle. Care should be taken to see that the lens opening in the floor of the fuselage is large enough to level the camera to a reasonable extent without having the floor of the fuselage cut off a portion of the lens area. The mounting should also allow the camera to be rotated in a horizontal plane enough to overcome the crabbing of the areoplane and it should be mounted on sponge rubbers to kill the vibration. If the camera is kept square fore and aft with the aeroplane, it is readily seen that each succeeding photograph will be stepped sideways. This shows plainly in our work in Indiana County. The camera, therefore, should be rotated until the center line of the camera is parallel to the line of flight.

To fly an area, a route map should be made. This is simply the best available map of the area, with the flying course plainly drawn on it in ink. You can see what I mean by studying the route map of the Schoolcraft, Mich., quadrangle, shown in Fig. 2. This shows the route map together with the picture positions plotted on it. These pictures were taken with a K1 camera.

The control system to be used in drawing accurate maps from a mosaic is rather a knotty point. For oil and gas maps the best and fastest method would be to obtain from the railroad companies whose tracks appear on the mosaic an alignment map of their respective roads. (This would apply only when there are no United States Geological Survey maps of the area.) This will allow various points to be obtained accurately and the rest of the map to be fitted to these points. Another method is to obtain the notes of the primary traverses which probably have been made by the United States Geological Survey. These primary traverses usually follow railroads and roads, with stations at road intersections and other permanent points. Or, possibly, the control could be taken directly from the geological map sheets in sections where these are available. These are a few of the methods which might be used.

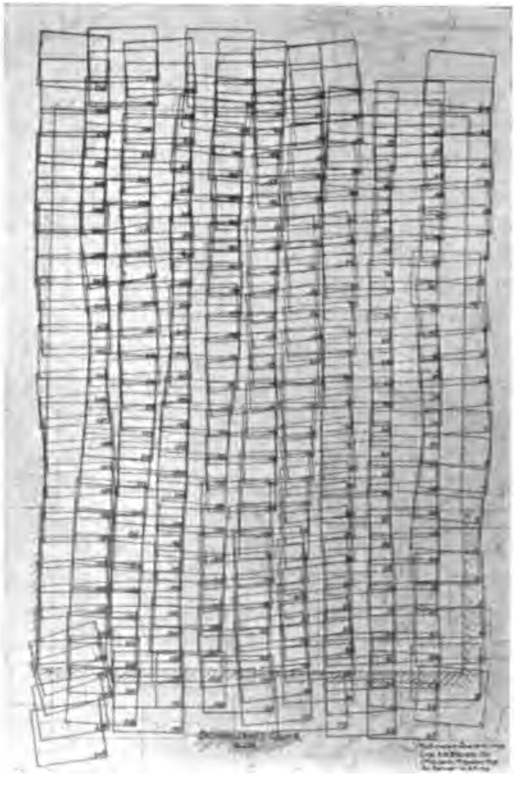

Fig. 2. Route Map of the Schoolcraft Quadrangle. U. S. Air Service.

Aerial photographs have already demonstrated their great usefulness in making corrections of existing maps. One instance is the revision of the Santa Monica quadrangle in California, made after an interval of 25 years. The photographic data were transferred to the new map by plotting of proportional distances, the data on the early map being used as control. In several instances small errors in the early map were discovered and corrected by the use of the photographs. The cost of these corrections is not clearly given, as it is stated in this way, "The cost of obtaining the first 1000 copies of the revised map was slightly less than $10 per square mile. This includes all items except the outlay for aircraft and the maintenance of the same."

When I conceived the idea of using aerial photographs for the base surveys of the gas field, one of the greatest uncertainties was the possible variation in scale due to hills and valleys. For instance, where the river hill and the river both show on one photograph the scale would be badly out.

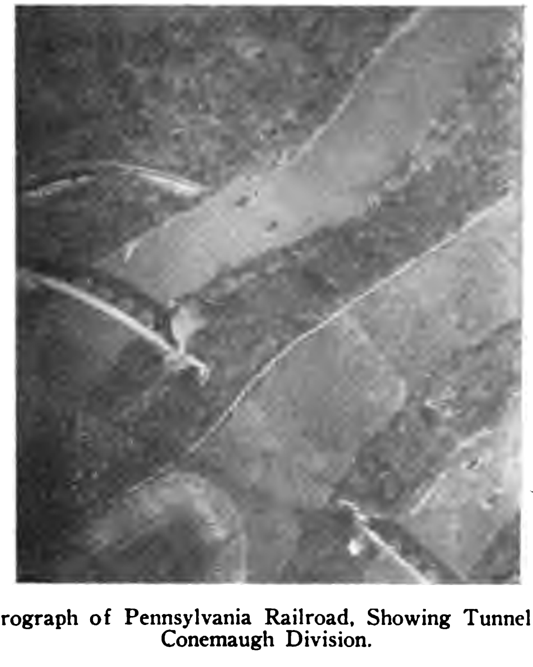

Fig. 3. Aerograph of Pennsylvania Railroad, Showing Tunnel and River. Conemaugh Division.

Fig. 3 shows to some extent the condition I mean. At the risk of seeming to contradict what follows, I will say that this question of error has not been settled very fully by me, and will not be until I get a mosaic that covers several hundred square miles of such country as we have in our gas field. The view in

Fig. 3 is a most curious one. First, the stream shown is the Kiskiminetas River flowing around a great loop at Tunnelton, Pa. The railroad which is shown, together with the two stone arch bridges, is the Conemaugh Division of the Pennsylvania Railroad, the location being about ten miles west of Blairsville. The railroad runs through a tunnel at this point. The cover of the tunnel is probably about 75 to 100 feet, though this is a plain out and out guess on my part as I have nothing more to go on than observations taken while riding past this point on a train. The sides of this ridge are steep and the top almost flat, except at the point where the corn-field shows. You can tell by the way the ground is plowed that the ground rises into a higher ridge or knob along the edge of the field. The next odd feature showing on this photograph is the old low-grade line of the railroad, the old bridge piers and the entrance of the old tunnel. I have never been on top of this hill, but it looks as though this old tunnel had fallen in, making a ditch or depression across the field on top of the hill. Note the straight line. The most interesting feature of this picture is the black spot (near the center of the picture), which shows the portal of the old canal tunnel where the old canal went through this hill. It would not be possible to check a scale from this picture as the elevation from which it is taken is not known positively, though it is about 4000 feet.

At the time our Indiana job started, one of our surveyors was completing a map, just north of Indiana borough, made by the stadia and compass method. We took a strip of photographs of a part of this terrain and compared various points of the photographs and the survey. The photograph mosaic was a trifle smaller than the survey, the error being about 0.6 of a foot in 100 feet, or a little over 32 feet in a mile. Comparison of the test mosaic with the United States Geological Survey map of this same area gave an apparent error of about 0.3 of a foot in 100 feet, or about 16 feet in a mile. After a careful study of the situation we decided the photographs were more nearly correct than our stadia survey, as they were consistently shorter. This is as it should be, as the stadia survey is somewhat too long, due to the method used. (These methods have already been described in the beginning of this paper.)

Another rough test was made. This consisted of measuring the distance from the top to the bottom of a hill, this distance being about 1000 feet, and the elevation of the hill being roughly 200 feet. Then, measuring the same line on the photographs, an apparent error was found of about 0.5 of a foot in 100 feet for the total distance. For the uses to which our maps are put, such an error is of no consequence. The test photographs were taken at an elevation of 4000 feet. If, on new work, an elevation of 8000 feet were maintained, these errors would be somewhat reduced. I am fairly certain that any errors which would show up in aerial surveying would not be greater than the errors which

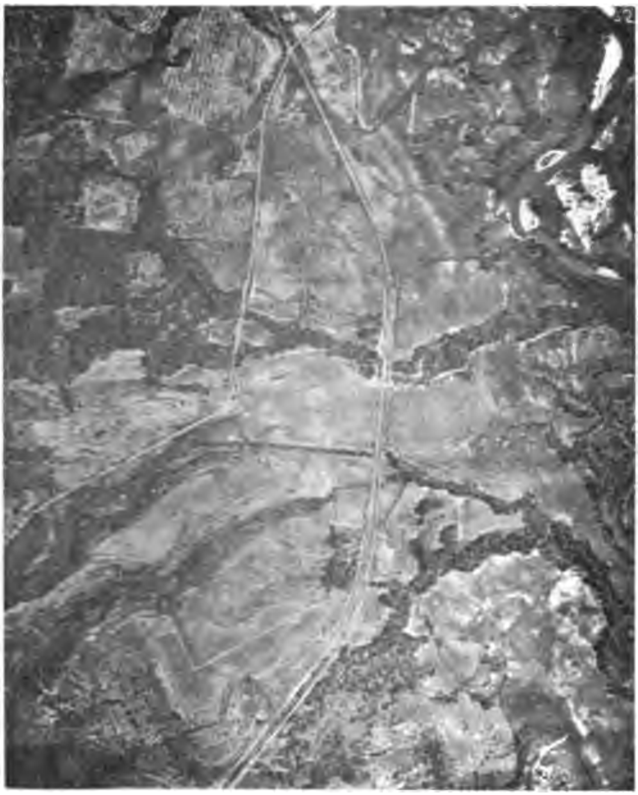

Fig. 4. Section of Terrain Near Columbus, Georgia. U. S. Air Service.

show in the ordinary survey unless an undue amount of money is spent in eliminating them.

Fig. 4 shows part of a mosaic of Camp Benning, Ga., and as it also carried a map of the same area, it might be well to examine it while discussing this question of accuracy. The scale is about 800 feet to one inch.

These are my deductions concerning the accuracy of aerial photographs made up into a mosaic. These conclusions check up fairly well with those of J. W. Bagley, Major of Engineers—conclusions of an error of about one foot in 100 feet. Major Bagley, in arriving at this possible error, assumes a terrain having a difference in elevation of 500 feet. The terrain over which these test flights were made had probably a difference in elevation of about 200 feet. This would bring the error down to somewhere near my figures. I am very willing to admit, however, that my tests and conclusions may be very inaccurate. The main trouble with my work is that we did not get enough done. The errors which are inherent to a mosaic when the pictures are taken over a rough country are such that the mosaic will be unreliable to scale distance from say 12 to 15 miles. I may qualify this statement somewhat in this way. If I read Major Bagley aright, the assumed area is 15 miles square; the probable error in this may be as high as 700 feet, or 46 feet in a mile. This would not be noticeable on a small scale map, and for oil and gas maps it would not be worth considering. However, this may not be a distributed error, as one-half of it, or 350 feet, might occur within the limits of one photograph, provided the elevation of the ground at one side of the picture were zero and that on the other side at an elevation of plus or minus 500 feet.

This point of error and just how it would affect a mosaic is one that I am not prepared to go into deeply. If I ever succeed in getting a mosaic which covers several hundred square miles of country, particularly the oil and gas field, it will settle many things which at present are hazy.

Other engineers are also considering the use of aerial photographs for map uses. Mr. George Rieg, mining engineer for the Rochester & Pittsburgh Coal and Iron Company, at Indiana, Pa., was much interested in our previous efforts in Indiana County.

He has conducted an independent investigation regarding possible misplacements of objects on the photographs. His conclusions are as follows:

With the camera at 5000 feet and a difference in elevation of 100 feet in 500 feet linear measurement, the displacment or error in scale would be about about eight feet, or 1.6 feet in 100. It would have been very helpful to check our ground against our photographs much more carefully than was done, but, due to the unsatisfactory condition our job got into, it was not expedient to spend any more money on work which at the time was a failure.

One thing you cannot do, as yet, is to obtain contours from the photographs. With a large magnifying glass the slopes can readily be seen, but the steepness of a slope or the height of a hill cannot be determined. The French and Germans both claim to have a method by which the contours can be plotted on the maps. This method claims an accuracy of about two feet as to position and less than four feet as to elevation. The method is somewhat similar to the three-point problem in plane-table work. It requires long and complex calculations and an elaborate system of ground control. The United States Geological Survey is working to get a reasonably accurate way of establishing contours from aerial photographs. This will undoubtedly come, in time, probably by the use of a tri-lens camera, with which two pictures are taken on angles while one picture is taken vertically. I am not well informed regarding this, and have not been interested in getting contour lines for our maps.

The cost of aerial work is an open question. The aerial mail is doing great work and is keeping accurate costs. An extract taken from a Post Office report covering the Washington-Philadelphia-New York route affords the following information. The total possible number of trips was 1263. Due to adverse weather conditions, 55 of these were not attempted, or as a percentage, only 4.4 per cent. were not flown. The number of miles possible was 138,310, and the number flown was 128,255, or a performance of 92.73 per cent. There were 193,021 pounds of mail carried at a total cost of $137,900.06, which was divided as follows:

	Cost per mile
Overhead	0.2829
Flying	0.2029
Maintenance	0.4081
Total	0.8939

During the year there were 37 forced landings, or one forced landing for every 3460 miles flown.

The United States Air Service has made a tentative estimate of the cost of covering an imaginary area, the data being as follows:

Area of 15 by 20 miles (300 square miles).
Location 50 miles from airdrome.
Scale of photographs—1 in 10,000, or about 833 feet to one inch.
Airplane to be used- DeHaviland 4.
Camera—Eastman K1 with 12-inch lens.
Area of pictures—Seven by nine inches.
Overlap wanted—Photographs to lap four inches on long side and three inches on short side.

On this basis the job was calculated to have 22 strips of 33 photographs each, or 726 photographs in all. The flying time was estimated at four days, and the items of expense which are in-included were as follows:

Gasoline and oil used in four trips from airdrome to area	$45.20
Gasoline and oil used in photographing area	102.20
Film used	198.80
Developing films and making prints	108.90
Total	$455.10
Approximate cost per square mile	$1.52

This estimate does not include any pay or expense of the crew, or any depreciation on the aeroplane. An estimate of these expenses would probably be about like this. One pilot, one photographer-observer, and one mechanic—each paid $200 a month. Their expenses would probably run $15 a day. The depreciation of the aeroplane could be figured at $250 a week, which is a very high guess but which will answer our purpose. This would make the total about $325 extra, or $1.25 per square mile, or a total per square mile of $2.77. This is based on pictures taken at an elevation of 10,000 feet. This is somewhat too high for a mosaic, and I would adopt 7000 as a standard elevation. At this elevation the scale of the pictures would be about 580 feet per inch, and the square mile cost based on the above estimate would be approximately $3.60. To be safe, this cost should be at least doubled, to take care of bad weather, etc.

A few figures on the cost of jobs completed by the United States Air Service are given below:

1. The Schoolcraft quadrangle, in Michigan. Area 220 square miles, at a cost of $3.24 per square mile.

2. Atlantic City, N. J. Area 35 square miles, at a cost of $0.65 per square mile.

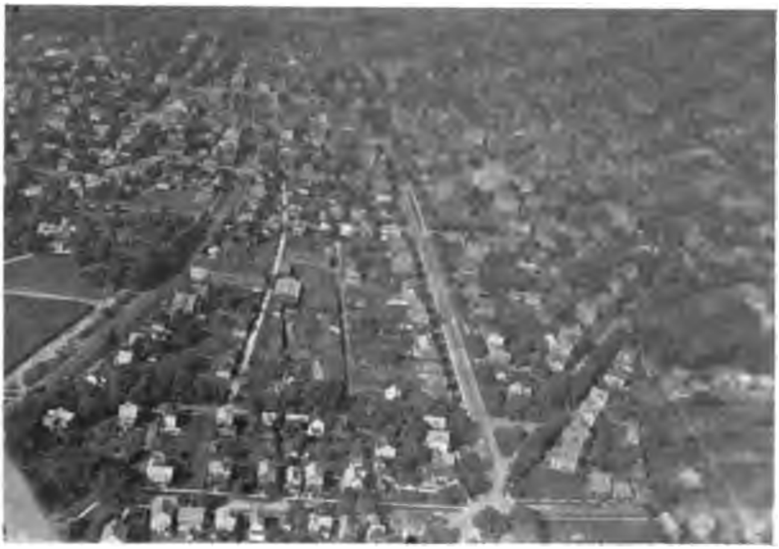

Fig. 5. Portion of Indiana Borough, Pennsylvania.

3. Camp Benning, Ga. Area 150 square miles, at a cost of $13.20 per square mile. The higher cost of this survey was due to taking a full photographic unit of 19 men (together with the transportation charges on equipment) from Langley Field, Va., to Camp Benning, Ga., the cost of which totals $1260.38.

4. Camp Eustis, Va. Area 46 square miles, at a cost of $10.80 per square mile.

Fig. 5 shows a section of Indiana, Pa. The photograph from which this is taken was made by Mr. Carl L. Douglas of Indiana, Pa.

A very useful application of the mosaic would be in the work of city planning or flood prevention. As I am not well posted in this line, you will have to draw your own conclusions.

A mosaic could also be used in planning work on water-sheds, or on a project like the Lake Erie-Ohio River Canal. It would seem that an aerial photograph of the possible routes would save a lot of personal inspection and scouting work, and also a good deal of surveying.

A mosaic could also be used to wonderful advantage in making plans for reforesting, as aerial pictures show all the details on the ground, something that no existing map shows.

Dr. Willis T. Lee of the United States Geological Survey, has written an interesting paper entitled "Airplanes and Geography."* Dr. Lee says in part, "The airplane opens a new world to the geographer, for some parts of the earth's surface can be conveniently observed and adequately illustrated in no other way than from the air." We surveyors certainly know a good many places in this territory which can not be observed "conveniently" by the ordinary methods.

Dr. Lee mentions the following uses to which aerial photography may be put:

1. Observations in well known areas, such as a city, in which there are many details to be shown.

2. Observations in such areas as marshes and swamps, in which many details may be unimportant and are usually omitted from maps and descriptions because the difficulty in obtaining them by ordinary methods is too great to warrant the necessary expenditure of time and money. This statement would also apply to many details of any survey—we would like to have them but cannot afford to pay for them, either in money or time.

3. Observations in submerged areas where information as to the underwater surface has been obtained heretofore, chiefly by soundings.

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*Geographical Review, 1920, v. 10, pp. 310-325.

The country as seen from a plane high in air has a striking resemblance to a map. For this reason aerial photographs properly taken and interpreted make excellent maps. The reader must know the meaning of the symbols used on a map, so the user of aerial photographs must learn to interpret them. By practice the observer soon learns distinctive characteristics. If aerial pictures are oriented so that the shadows point toward the observer, hills, hollows, buildings and trees appear natural. If the print is reversed, the hills may have the appearance of hollows. Forests are easily distinguished from brush, and even the kind of trees may be recognized by the characteristics of their growth. Orchards may be identified by the even spacing of the trees. Paved roads may be distinguished from unimproved roads and byways. Bridges, fords and a great variety of objects may be known by some distinctive peculiarity.

Another use for aerial photographs is in checking charts which show channels, sand-bars, etc. The pictures will, of course, not show depth of water. They will however, show the bottom which is covered with as much as five or six feet of water, and the darker streaks which show in the stream indicate the channel. It is quite possible, judging from the results obtained from photographs taken both over Chesapeake Bay and the Potomac River, that a series of pictures taken over a river would give a close indication as to the location of the channel.

This subject has so many ramifications, especially as to the effects of various lights on water, that no very definite information is as yet available. Dr. Lee brings up this subject of light, which has not been touched upon. He says that in photographing over water, a day when the sky is either perfectly clear or when it is evenly overcast, is best. In photographing over land the same conditions would probably hold true, provided the clouds were what might be termed light ones. The one difficulty in trying to work on a cloudy day is that the clouds may not be high enough to allow the plane to be below them at heights of from 7000 feet up.

Thanks are due to C. H. Birdseye, J. H. Wheat and Willis T. Lee, of the United States Geological Survey, and to Capt. Hartney and Major Bagley of the United States Air Service for the interest that they have taken and the time they have spent in informing the writer regarding various aspects and possibilities of aerial surveying. Any accurate information that this talk contains is undoubtedly due to their help—I can make my own mistakes.

Great credit should also be given Messrs. T. W. & B. D. Phillips of the T. W. Phillips Gas & Oil Company, for the encouragement they have given me in what may be classed in some quarters as a harebrained idea.

In closing I would like to enlist the interest of local engineers in three things. One is to help in obtaining local landing fields. Pittsburgh should be an air port and have a good landing field right now. The second point is to maintain and enlarge the aerial mail service and also the aeroplane service of the Army and Navy. This may not be a financial success, but it trains personnel and helps the industry as a whole. The third point is to secure some laws governing the use of the air. This should be made a national matter, as, from the very nature of things, it is impracticable for the separate states to handle it. All the European nations have air codes, and it is time we had the same.

DISCUSSION

DR. GEORGE H. ASHLEY:* The subject of aerial photography as applied to surveying has been of great interest to the members of the Pennsylvania Geological Survey and the United States Geological Survey, as both of those organizations have been on the lookout for any process which would either increase the accuracy of the topographic map of the state now being made, or that would reduce its cost without decreasing its accuracy. Considerable reduction has been made in the cost during the past year due to the use of the surveys made for the State Highway Department. After a careful test of these surveys, it was found that they would serve the purpose, and it is estimated that through their use the cost of primary control has been reduced for each sheet from about $1200 to $200.

The possibility of the use of aerial photography for bringing old topographic sheets up to date as relates to cultural data, has been under discussion for some time. The possibility of using the aeroplane and camera in the first making of the survey has been discussed but has not yet led to definite plans in that direction. The Pennsylvania Survey. however, will watch with great interest the success of the work proposed by Mr. Mandeville's company, and if it shall prove as successful as is now hoped, it is probable that the Pennsylvania Survey will take up the matter with the view of using that method of mapping for the 40 per cent. of this state still to be mapped.

It is believed that this mapping should follow the primary traverse and other primary control work now being done, using for that purpose, of course, the State Highway Department surveys, supplemented by the necessary triangulation. It would seem that this should be followed by the placing of lettered or numbered targets on the principal triangulation points and possibly at other points which would serve as an aid in aligning the photographic mosaic when made. It is recognized that the making of a photographic mosaic will not take the place of the vertical control and topographic drawing but will take the place of a large amount of horizontal control including secondary triangulation, secondary road traverse, the traversing of streams, and other features of the work that make up a large part of its cost.

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*State Geologist of Pennsylvania, Harrisburg, Pa.

MR. GEORGE RIEG:* After having read the paper, with which I am in full accord for the most part, I am reminded that practically all of my information on this subject has emanated from Mr. Mandeville and that I am not even keeping the pace that he is leading. It seems better for me to leave further development with those who are at least familiar with the present status, technically qualified, and sufficiently gifted with originality and imagination to visualize the unknown.

It may be disappointing, especially to Mr. Mandeville, to learn of the simple conclusions with which I have satisfied myself. However, a photographic map always contains certain errors, varying with the extent of undulations in the terrain, and it is and must remain mathematically impossible to adjust all photographed points to true relative positions on any common plane without otherwise determining vertical relationship; and even then such adjustments would necessarily be so impracticable as to defeat the point.

After detracting this much from the possibilities of a photographic value there remains, nevertheless, for immediate application, a photographic realization that would serve as a record of what would have appeared to the eye from the same viewpoint at the same time. Such a record, witness, or what one may choose to call it, represents, or may later develop, a value according to what landmarks or other information it may record. Such possibilities of value depend much upon what may be lost or obliterated through lapse of time and can best be appreciated by those with more experience. As a map containing limited errors which may be known or can be determined, the photograph represents many of the most important physical features of a territory in such a comprehensive way that there is very little possibility that they might convey a false impression of the territory or any details that might be of special interest, or even relative positions of details.

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*Mining Engineer, Rochester & Pittsburgh Coal & Iron Co., Indiana, Pa.

There are no maps to be found showing full information derived from positive surveys except for very small areas, and compilations from surveys made at different times, for different purposes, and at a total expense not justifiable for less than all of the several purposes.

How safe such a statement may be against challenge, each may decide for himself, but the outstanding facts are that completeness is usually achieved at the end, whereas its greatest value is at the beginning, at which time the ultimate possibilities of most industrial enterprises are predetermined and often limited according to the extent of available information. To eliminate positive surveys entirely, remains as hopeless as to have positive maps of unsurveyed territory right now. Photographic maps can best span the gap between nothing and the best, and there seems no good reason why they should not forthwith take a place in the industrial world similar to that of "first aid to the injured." What further favor they may gain depends largely upon just how much they will reduce the industrial doctor's bills.

Having reached this point where we lack definite information, there seems no better way to progress than to adopt a program of initiation and development rather than follow that of perfection before initiation. With this fresh grip upon the subject in question, I sincerely believe that the bills could be reduced very substantially, that additional information could be procured through co-operation with other allied enterprises, but that none of this should be hoped for so long as industry finds the old reliable family doctor to be the first and only respondent to its calls for help, who directs his efforts to relieving the situation as well as to further study and work on the case.

MR. H. M. KANARR:* The subject so ably presented by my friend Mr. Mandeville, has, in my judgment, much greater advantages probably in his particular field—gas and oil production—than possibly any other of the engineering lines in times of peace. It is well, however, to bear in mind his warning, and not to expect too much of what must necessarily be a photograph and not a map, in the ordinary sense in which these terms are used. In conjunction with existing maps, or with some form of ground control, they are of undoubted value.

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*Civil and Mining Engineer, Punxsutawney, Pa.

For use in connection with projected railroads, they would show quickly whether proposed routes might be feasible, and thus eliminate from further consideration those that were not. A more careful preliminary investigation however, would be required to show even the feasibility of a proposed route, to a certainty, since the element of elevation as it would affect the grade of the road, could not be ascertained from the mosaic.

From the standpoint of the coal-mining engineer, the plan offers a convenient way of bringing to the attention of the executives, the features of the terrain under which or upon which, operations may be contemplated or in progress. This would apply particularly to large companies, whose executives are not familiar with such details of their property. As a rule the chief engineer of such a company will be, or at least should be, thoroughly familiar with such features, from his personal observation. It occurs to me that he should, with the aid of his assistants, be able, from the physical features of the mosaic, to locate thereon the boundary lines of the farms or properties, particularly in a farming community where fences, roads, or streams usually mark these property lines. From these property lines, the position and direction of the principal entries of the mine could then be located, by scaling from the mine or property maps, which of course will never be dispensed with or displaced by the method under discussion. Such a combination map and photograph would be available in connection with many problems arising from mining operations, such as the location of new openings for hoisting, ventilation, or drainage. The map would not be valuable so much to those familiar with the property, as to those whose duties do not put them in such a position, but who from the responsibilities of their position must make decisions on these questions.

By aerial photography streams or bodies of water might be located with sufficient accuracy for the regular mine maps, since a matter of five or ten feet is not of much consequence in the location of the shore line, owing to its irregularity and changeable character.

For other features of topography for mine maps, such as roads and buildings, the method would scarcely be applicable, I think, on account of the unavoidable inaccuracies involved.

MR. E. H. CORLETT:* I wish to say that I appreciate the opportunity to hear and comment on Mr. Mandeville's paper to night. I will say, first, that his paper conveys to my mind no false impressions whatever. Compared to the claims of most "air people," his paper is an oasis of sanity in a desert of very hot air. I have very little with which to disagree and but very little which I wish to supplement.

An aerial map covering a certain territory serves not merely the oil and gas man but also the road engineer, the railway engineer, and all engineers interested in the development of the terrain photographed. Those who desire an aerial map of the land in which they are interested would do well to consider this, because the cost of furnishing this map within certain limits varies almost inversely per unit as the area of the land.

On the contract I am now completing in Cuyahoga County, O., the specifications call for a scale error, on any one picture completing the mosaic, of a maximum of one per cent. on any one horizontal plane. We do this by running our stadia controls to an error of less than one in five hundred. Then, on a projection board, four points supply data for the correction of perspective and scale.

Mr. Mandeville mentioned the Glen Martin twin-motored aeroplane as probably best suited for photographic work. Personally I think that the only advantage would be that the operator would not be subjected to the propeller blast. From all I could learn, the idea of one of two motors carrying a loaded aeroplane is a myth, practically. It is my belief that a machine like the 30-foot-span Ansaldo with a capacity of 1000 pounds including human freight, and a ceiling of about 20,000 feet in less than an hour, and with a landing speed of about 45 miles an hour, more nearly approaches the ideal for photographic work than anything we have (I say this as a result of study and not of experience—my flying was sub-contracted to a Curtiss distributor, who used a Canuck and a Standard. The Canuck was overloaded and the Standard was good to about 5000 feet).

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*General Manager and Engineer, Corlett Aero Map Co., Cleveland.

Personally I am for the K1 camera, the original type. The new K1 has, in my opinion, refinements not warranted by their cost and their utility. The Bagley camera was not designed to make an aerial map, but to supply data from which to construct a topographic map. I quote Mr. Moffit who was associated with Major Bagley in the development of this camera. It is obvious that a rectified oblique picture will screen a great many details, especially in cities, forests, and bad lands.

The cost of the aerial map, from the standpoint of material and flying alone, is very small. Therefore, I believe in taking a large number of pictures and using only the heart of each. Ordinarily, I would limit the angle of view to 10 degrees.

This is not meant to detract from the Bagley camera, because it is a marvel in its way and will undoubtedly be of great use to the United States Geological Survey along the lines outlined by Mr. Moffit.

There should be no blur due to vibration; the camera should be mounted on comparatively elastic supports so that the plane of the supports passes approximately through the center of gravity of the camera system. The bubble is a nice thing to have on the aero camera and has its uses, but it is only a pendulum and, like a pendulum, is valueless if the aeroplane travels on any sort of a curve. The gyroscope shows considerable promise but it too has its limitations. If it be accidentally displaced when once in the air, it cannot be set again before landing. I have my own idea of a device either to register divergence from the vertical or to hold the camera vertical; but I shall not disclose it until I am satisfied that it is practical.

With the K1 camera the altitude very closely approximates twelve times the scale of the negative. Provided clouds do not interfere, at elevations of 7000 or 8000 feet, I am very much in favor of 12,000 feet as the ideal altitude. Now, here is where a machine that will function even as high as 24,000 feet comes in handy. Let the pictures be ever so poor, so long as most details are discernible. It takes no more control to locate and possibly correct a photograph covering nearly ten square miles than it does one covering half a square mile. Once a mosaic is made of such pictures the pilot and operator have an incomparable chart for operations at any lower altitude; and the draftsman who will build the final mosaic or lower altitude pictures have a control sheet which cannot be questioned. Personally I do not excuse excessive stagger or insufficient overlap.

Where two pictures cover the same area, the right sort of technique will furnish the engineer with stereoscopic views, and these stereoscopic views enable the user actually to see even small differences of elevation on the terrain. Aside from being of pictorial value only, the person constructing the mosaic can, by matching, make allowances for estimated differences of elevation. This, by the way, is more than likely the basis of the claims of the French and Germans, of whom Mr. Mandeville speaks, as to construction of contour maps from aerial photographs. I may remark in this connection that this is no myth—it is a probability.

In this connection I may give a formula for the effect of relief on the negative:

$$r = \frac{ph}{A-h}$$

in which r is in inches, and ρ is the distance in inches, to the point on the negative the elevation of which above the datum plate is h feet, considered algebraically, from the point on the negative vertically below the lens (generally we may safely consider the center of the picture as this point). A is the altitude in feet. Therefore you will see that what is commonly called error should not be called that. Also in estimating h, a quite large error makes but a small error in r. Naturally, the corrections are radial to the center as assumed. Error is really a function of the unwitting variation of altitude on the part of the pilot, and the angular displacement of the camera from the vertical at the instant of exposure. Peculiarities of shutter and lens, and shrinkage of paper etc., are all less than the allowable error of any good feature map.

In considering cost we should separate it into two parts, namely; that proportional per unit to the area and depending upon scale; and that inversely proportional per unit to the area, depending upon how nearly continuously we can keep our equipment busy. For the first mentioned cost we allow according to the formula:

$$Cost = \frac{100}{S}\left(\frac{20,000 + 3S}{S}\right)$$

In this formula, S is the number of feet per inch of the negatives—the scale. For the second cost we charge $2000 a month to keep aeroplane, pilot, operator, and mechanic, ready for action. I may mention in passing that I am asking $3000 for 60 square miles of forest land, roughly in a square; and, about $80,000 for 2000 square miles of forest land. In each case, we guarantee to fit the township survey net within two per cent. The contract I am now fulfilling with the one per cent. guarantee is costing the client about $250 a square mile. In this, however, the survey alone on 34 square miles will cost about $70 a square mile. They should cost in the summer about $30 a square mile, and maybe less. On the job of 2000 square miles mentioned above, I will deduct ten to fifteen dollars a square mile if I am not held rigidly to a percentage.

The Laurentide forester showed me some of his work in a Canadian wood. In pictures from an altitude of 5000 feet different types of trees were readily distinguishable. Personally I doubt very much if the forest remnants we have in most of the Middle West would yield like results—certainly they did not on the contract I am now working—or perhaps I am not well enough versed in the matter to take advantage of what they do reveal.

I may say in conclusion that if I have time this spring I expect to have an article in each of the following: *"The Highway Engineer and Contractor," "Engineering-Contracting,"* and the *"Engineering News-Record."* I will be able therein to discuss this matter from several different angles. In the meantime, I will welcome suggestions, and records of experiences. We all prosper by pooling our knowledge.

MR. W. L. SCOTT:* Aside from their element of novelty, aerial photographs have undoubtly qualities of beauty and utility. The birds-eye view has always been a favorite for revealing to the best advantage the entire form and location of buildings, and other large objects. Heretofore such views have usually had to be drawn by an imaginative artist.

Aerial oblique views possess the combined value of pictures and of plans. They are likely to be extensively used in the study of architecture, cathedrals, public buildings and sky scrapers, particularly those in their cramped surroundings where they can never be seen in their entirety, from the ground. They come forth in all their beauty, or quaint proportion, from the airman's point of vantage. Prints of the famous buildings of Europe or America taken from the air will give to the prospective traveler or the people at home a much more accurate idea of their construction than will any number of mere surface views.

A vertical aerial photograph is closely akin to a map but has advantages over any ordinary surveyor's product. As a guide, it is infinitely superior to the best draftsman's diagram, for it provides a wealth of detail whereby the traveler definitely locates himself at a single glance. He notes the objects of interest within his radius of easy travel. The guide-book of the future will therefore be incomplete without numerous aerial views, both vertical and oblique.

Aerial photographs will undoubtedly be widely used in certain fields of advertising. Architects and real-estate agents may be expected to display their wares by the aid of aerial views. A well planned country estate or golf course or a suburban development can be shown with a completeness, both as to environment and stage of progress, which no other form of representation can approach. A seaside resort can now show its natural and artificial amusement features in a single picture. Even the extent of its bathing beach under water is revealed in the photograph.

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*South Penn Oil Co., Pittsburgh.

Real-estate agents can utilize aerial photographs of cities to great advantage. On these, their properties can be pointed out and the nature of their surroundings shown at a glance. The future purchaser of lots in a distant boom town will no longer be satisfied with a map outlining the streets with high-sounding names. He will demand an authentic aerial photograph showing the actual number of houses under construction, the streets, gutters, and sidewalks already laid, the size and planting of trees.

Landscape gardening is a field for which the aerial photograph is peculiarly fitted. A collection of oblique pictures will be worth more to the designer of a country estate than maps and ground pictures can ever be. Closely allied to landscape gardening is city planning, for which the aerial map will be quite indispensable. The appearance of the city from the air may, indeed, become a matter of pride to rich inhabitants, and not only the arrangements of streets and parks but even the character of the roofs of the buildings may be subject to study.

Engineers and contractors will depend more and more on preliminary photographic surveys as a basis for locating their operations. At the later stages of their work they will use aerial photographs for reporting progress. Periodic photographs of buildings and progress of construction are much more illustrative when made from the air; as, for example, the Emsworth Dam, down the Ohio River. Only from above, is it possible to obtain in a single picture the progress of the complete project, such as the construction of a dam, large manufacturing plants, etc. The building of large structures, bridges, hotels, ships on the stocks, etc., particularly demand aerial views, if the foreground is not to eclipse the center of real interest.

The photographing of fires, floods or wrecks, suggests the importance of aerial views to insurance underwriters who require the most minute information on the characteristics of buildings in every neighborhood, and on the extent and nature of damage done. Marine insurance companies might with profit use the aerial camera to help estimate the chances of salvage of a stranded ship or vessel foundered in shallow waters.

City mapping is a field for which aerial photography is peculiarly fitted. A complete survey map of a large city is a labor of years. In fact, a modern city is always dangerously near to growing faster than its maps. An aerial map can be produced in a few hours. Paris was mapped with 800 plates in 24 hours, flying time. Washington was completely mapped by Sergeant-Major Hazlett, of the Royal Flying Corps, who was my first instructor, in 2.5 hours flying time, with less than 200 exposures.

MR. J. HAMMOND SMITH:* Will you tell us something of the details of your camera.

MR. W. L. SCOTT: There are two types of camera, one vertical and the other held in the hand and used for taking oblique views or views at an angle. My work last year was practically all with a hand-held camera. For engineering work, like the Emsworth Dam, an aerial photo would show in detail everything that is being done. If you took a dozen views on the ground they possibly would not tell as much as one aerial photograph. In my work last summer I used the British Admiralty camera almost altogether. I used it over the side of the ship, with a strap over my neck. Aerial cameras are quite expensive. The K1 that was spoken of, costs a little over $1000 without fittings. The British Admiralty type costs $400. A trigger operates a shield in front of the lens, which is a protection from the oil from the motor that might in some cases put it entirely out of commission.

MR. L. P. BLUM, *Chairman*;† On what principle does the altimeter work?

MR. W. L. SCOTT: The one most in use is the aneroid barometer type. If it is set at zero at Leetsdale and shows an altitude of 1200 feet over Squirrel Hill, that does not mean that I would be 1200 feet above Squirrel Hill, for that region is 300 feet higher than Leetsdale and, therefore, I would be only 900 feet above Squirrel Hill. Criticism was made of the fuzziness of the pictures. I have come to the conclusion that you can pre-

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*Professor of Civil Engineering, University of Pittsburgh, Pittsburgh.
†Blum, Weldin & Co., Pittsburgh.

vent that almost entirely; but when taking pictures straight down it is a pretty hard proposition to counteract the vibration entirely We used tennis balls, and, better yet, bedded the camera on a lot of sponges. Then the camera jiggled more or less sideways, so I sat on it and practically eliminated the vibration.

Mr. H. D. Brown* Has the camera taking pictures while in motion been tried with any success? One readily realizes the fact that for map purposes a still picture is requisite, but the idea occured to me that something might be devised on the order of a panoramic camera, such as is used in taking a large group of people, for instance. Taking a long strip of picture might eliminate some of the tediousness in matching up a number of small photographs. At least one could have a continuous strip of each "run" of the areoplane over the terrain to be mapped, and these could be matched instead of a number of small pieces. Of course, the main drawback would be the inability—in the present stage of the art of flying—to keep the ship at one level, so that the whole strip would be to the same scale. This, no doubt, will be overcome in the near future.

Mr. W. L. Scott: Yes, but it is more for pictorial purposes. You can not study a moving picture well for you do not have time to pick out small details. That is why during the war moving picture cameras were very little used. They are nice to look at. but for engineering work they are of very limited value.

The processes in aerial work are radically different from ordinary photography for good results. It might interest you to have a little of the history related. A man named Brabazon, in the British Army, stated in 1914 that it would be of advantage if the flyers would take pictures of enemy territory. He started on his own hook and used a little box camera and got quite a few fairly good results, but the pictures were very hazy. He figured that the ultra-violet rays in the atmosphere had an excessive effect on the photographic plate so he started using filters and special emulsions and allowed only the rays he wanted to register on the plate. In 1915 Major Campbell got through the War Department

*Draftsman, National Tube Co., McKeesport, Pa.

an order letting him go ahead with it. In 1916, in less than a year, every army was using aerial cameras, though an aerial photograph was unknown except for kite photography before 1915. It is entirely a new science developed in the last five years.

MR. C. B. STANTON:* I would like to ask if anything has been done along the line of combining photographic surveys, such as the type used on the Alaskan boundary survey, with the aerial plan in order to get the topographic features?

MR. J. B. MANDEVILLE: No, I do not think so. I saw the last one and there were no photographs in the book at all, simply maps.

MR. C. B. STANTON: Has anything been done toward co-ordinating with the aerial work and taking the photographs from the prominent control points like primary or secondary triangulation points, noting the magnetic bearings and thus getting a complete topographic map?

MR. J. B. MANDEVILLE: Not that I know of. Major Bagley started that in having his camera set at the different triangulation points and taking a swing. But that was strictly a horizontal picture, and that was checked against manual surveys.

MR. C. B. STANTON: My idea is to take your aerial map or plan as a basis and by the use of photographs from control points thus obtain relative elevation. It is apparent from the discussion that one man is interested in the plan and scale, while the other is interested only in getting a good picture. In order to get a good map, there must be some co-operation between the two.

MR. J. B. MANDEVILLE: It is possible, but I never heard of it being done.

MR. E. H. CORLETT: My experience in interpreting photographs would lead me to avoid that just as far as possible.

MR. L. P. BLUM: In the consideration of the subject of the evening, I was very much impressed with the thought that Mr.

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*Associate Professor of Civil Engineering, Carnegie Institute of Technology, Pittsburgh.

Scott suggested—the very rapid development of the art. When we consider that almost the entire history of photography and aviation has been written during the lives of the present generation, it gives us an idea of how fast we are traveling. I was a student in the High School in Philadelphia at the time Langley's experiments were conducted in Washington, and I remember one of our professors coming out of his room chuckling over a joke which he had seen in the paper. An old army officer was asked what he thought of these experiments in flying and his reply was this: "If God Almighty intended men to fly He would have given them wings." This is just illustrative of the opinions of a few years ago, as compared with the accomplishments of to-day.

I am glad the author of the paper stressed this subject of the degree of accuracy and did not make extravagant claims. Those who have been engaged in topographic work know that stadia topography even of a rough kind costs more than $40 or $50 a square mile. Possibly stadia methods produce work with a higher degree of accuracy; but they do not obtain the same amount of detail as a photograph, and it goes to show that there is a field right here for the aerial photograph.

Those of us who have studied this proposition of accuracy in surveys, know how much this means. As a rough statement I would say that in the attainment of any degree of accuracy greater than one per cent. every halving of the error doubles the cost of the work. It becomes, then, a matter of vital importance to determine the degree of accuracy required and to adjust our methods of location to fit the end desired.

MR. J. B. MANDEVILLE: I asked about it in Washington the last time I was there and was told the only reason Langley's airship did not fly was because Langley did not have the gas-engine.

MR. GEORGE KETCHUM:* Glenn Curtiss put a gas motor on the Langley airship about five years ago and made successful flights with it.

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*Publicity Manager, Citizens Committee on City Plan, Pittsburgh.

CONTINUOUS ROLLING-MILLS

By JOHN W. SHEPERDSON*

INTRODUCTION

The continuous process of rolling is the most scientific method of forming metal so far discovered. It is for this reason alone that out of the round 30,000,000 tons of present-day annual production of hot-rolled steel in the United States, at least 30 per cent. is roughed or finished in continuous mills. It is true that the construction and operation of continuous mills involve many difficult problems and require greater experience than with other types of mills; nevertheless, the continuous process of rolling is being rapidly extended, particularly in this country, to many new lines of product, thus ever increasing the proportion of the total tonnages rolled on continuous mills.

Changed labor conditions in other countries as the result of the war make necessary the use of improved labor-saving machinery, and many continuous mills are now being laid down in Europe.

For the mechanical treatment of steel some process better than rolling may be discovered; but, as long as rolls are employed, there seems to be no prospect of equalling the continuous mill in the following important and fundamental features:

> The practicability of finishing very long lengths, limited only by the ability to handle the finished product.
>
> The possibility of uniform heat treatment from end to end of a bar of any length, due to uniform time and exposure from furnace to finishing pass.
>
> Low power consumption, due to rolls of small diameter.
>
> Low fuel requirements for heating, because of rapid rolling and short exposure.
>
> Freedom to use the maximum size of roll neck, due to two-high construction.

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*Engineer, Morgan Construction Company, Worcester, Mass.

The continuous mill is commonly thought of as being the last type to be conceived and put into practical use, and few people realize that it began its existence in the same period in which other types of mills were taking form. The decade between 1856 and 1866 saw the inception and establishment of several distinct types of mills now in use.

In the same decade—in the year 1862—George Bedson of Manchester, England, built and operated the first continuous rod mill. Fig. 1 shows the second mill built by Bedson in 1868. It is still running and doing good work. The first mill laid down in the United States was made from the same patterns. It must be observed that the mill consists of alternate horizontal and vertical rolls. As first built, it was straight continuous from end to end. In 1896 it was divided into two parts.

Though the credit of building the first continuous mill belongs to England, it was in the United States that Charles Hill Morgan of Worcester, Mass., took up the development of this type of mill and in his life saw it reach a place of great importance, due to the American ingenuity of himself and his associates. It was quite natural that the New World with its younger steel industry should have taken up this advanced method of rolling. American capital was willing to provide special mills for the development of standardized products and so gave the continuous mill the necessary impetus in its early life to reach the high place which it has held by demonstrated merit.

With these general remarks, I will now take up the various well defined types of continuous mills.

CONTINUOUS BILLET MILLS

A discussion of continuous billet mills naturally involves a discussion of the use of small billets, which these mills have made available at very low cost. Before continuous billet mills became an integral part of blooming mills, the four-inch by four-inch billet held the field. The reason this billet established itself so firmly, is that it was the smallest size the ordinary blooming mill could roll, and maintain any semblance of output. When smaller initial

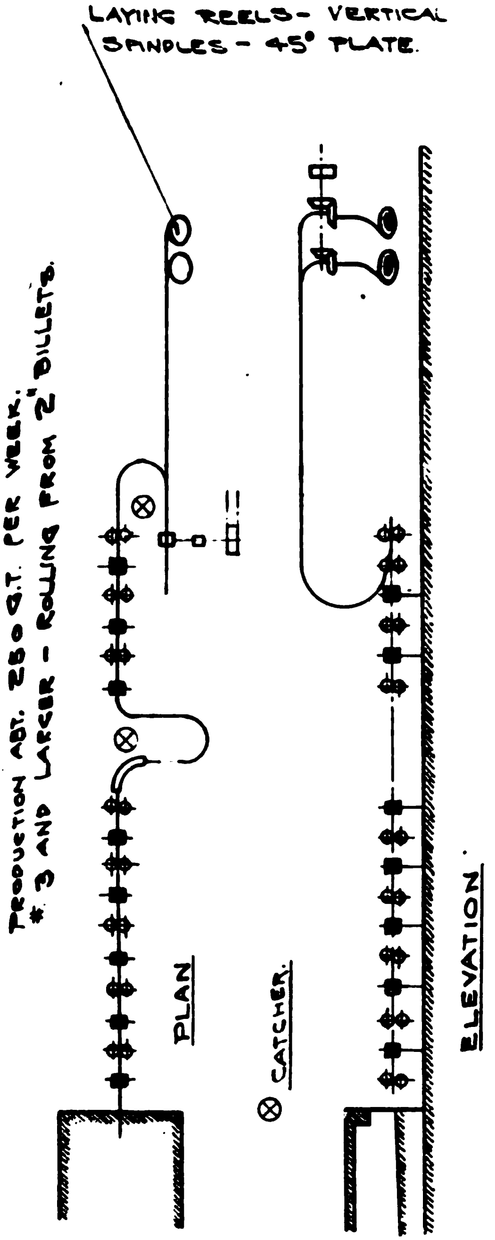

LAYING REELS - VERTICAL SPINDLES - 45° PLATE.
PRODUCTION ABT. 250 G.T. PER WEEK.
# 3 AND LARGER - ROLLING FROM 2" BILLETS.
PLAN
⊗ CATCHER.
ELEVATION

Fig. 1. Continuous Wire-Rod Mill at Works of Richard Johnson and Nephew, Manchester, England.

sections were needed to satisfy the requirements of small mills, they were secured by special means.

The development of continuous and other finishing mills to take small billets came simultaneously with the necessity of giving relief to the blooming mill, which, as a link in the production chain, was becoming severely taxed. It was, therefore, quite natural that, when the design of the continuous billet mill was undertaken, the following were the major aims:

> The securing direct from the ingot heat of as small a billet as was adaptable to subsequent use in finishing mills.
>
> The starting of the continuous billet-rolling process from a section enough larger than a four-inch by four-inch to afford the desired relief for the blooming mill.
>
> The rolling of the product of a whole ingot in one undivided length, to reduce to a minimum the losses in crops and shorts.

MINIMUM BILLET SECTION

In the interests of both the continuous billet mills and the mills which use the billets, a standard length is necessary. The practice of using four-inch by four-inch billets of every imaginable length, cut specially for each order, increases discards and throws an entirely unnecessary burden on the operating force in the mill and stock yard. The 1.75-inch billet is in the main the minimum commercial section and has firmly established itself as a standard for a multiplicity of uses. It represents 100 elongations from the usual ingot cross-section. A No. 5 wire rod represents in turn 100 elongations from the 1.75-inch billet, which makes 1.75 inches a logical size at which reheating should be done. The 30-foot 1.75-inch billet makes a rod bundle of 300 pounds, a suitable and popular weight in American wire mills. Furthermore, 30-foot lengths fit conveniently into railroad cars and can be very easily loaded and unloaded in heavy lifts.

In the development of passes for the production of 1.75-inch billets, it was obviously necessary to bear in mind that not in all cases would the 1.75-inch billet be the most advantageous section for subsequent rolling; and, as a consequence, suitable larger sizes were chosen and incorporated in one set of continuous rolls. Furthermore, provision was made to obtain 1.5-inch billets for purposes where special conditions call for a similar initial section.

THE SECTION ENTERING THE CONTINUOUS BILLET MILL

The size of the section entering the continuous billet mill depends upon local conditions and varies directly with the extent to which the blooming mill is taxed by the steel making capacity back of it.

When a small beginning is being made and the blooming mill is not taxed, a continuous billet mill of six stands can be employed, in which case the entering section is from 16 to 20 square inches. In such cases, provision is usually made for the interposition of additional continuous roll stands between the blooming mill and the billet mill for later tonnage development. Even in this case, the problem of dividing the work between the blooming mill and the billet mill is not clear cut. Quite frequently, an investment in an excess of soaking-pits proves attractive in order that the blooming mill may run single turn while the steel-making plant is running 24 hours. Under these conditions, in order to maintain a high rate of output during its own operating time, the blooming mill should be relieved of all extra passes by the installation of a 10-stand billet mill divided into two parts and receiving a bloom section of about 42 square inches. Such a combination, quite apart from its value in having sufficient capacity in a single turn to keep step with the plant, will also have ample capacity for promptly clearing congestion due to bunched heats.

Eight passes, corresponding to an entering section of 25 to 30 square inches, are used very rarely in a permanent layout, and the conditions must indeed be very special to justify this rolling program. In such an instance, the eight passes are arranged in straight continuity without interruption. The point beyond which it does not seem advisable to extend pure continuous billet rolling is about 64 square inches of entering section. The billet mill for such a size should consist of two parts, each having six passes.

ROLLING OF PRODUCT OF A WHOLE INGOT IN ONE LENGTH

The usual present-day ingot weighs about 7000 pounds. The rolling of a whole ingot of this weight into 700 feet of 1.75-inch billets is entirely beyond the limitations of any other than a continuous mill coupled with a flying shear. The invention of the flying shear by Victor E. Edwards has removed practically all limitations of initial ingot weight and has given to the steel industry a piece of equipment which unquestionably has done more to maintain yields at a very high figure than any other machine. It has also made the combined blooming and continuous billet mill realizable and has given these mills their present-day tonnage making ability.

If one were entirely to disregard the low operating cost of the continuous system as compared with any other rolling scheme, the high yield, the direct outcome of rolling long lengths, alone would be found to justify the continuous billet mill.

CONTINUOUS SHEET-BAR MILLS

Sheet bar, like billets, is an intermediate product rolled direct from the ingot heat in continuous mills. Until recently sheet bar was used almost exclusively in eight-inch widths, but present day practice is properly extending the range of widths up to 12 and 14 inches in the heavier foot weights. This results in economies at the sheet mills.

Since practically the same considerations govern the design of continuous sheet-bar mills and of billet mills, the two mills are frequently combined, and one or the other product is produced by changing the rolls. Roll speeds in such mills are governed not by the sheet bar, but by the billet passes.

The demand for width variation in sheet bar has led to a departure from the tongue-and-groove method which was used generally when sheet bar was confined to an eight-inch width. The combination of cylindrical rolls with vertical edging rolls, now affords a maximum of flexibility and produces sheet bar accurate in width, with clean edges, and of very uniform foot weight. One of the edging mills is located in front of the first pair of rolls of a six-stand sheet-bar mill. Its function is to perform the major part of the width reduction and to crack the scale, leaving a slight reduction for the second edging mill, located immediately following the second pair of horizontal rolls. This second edging pass is merely to iron out the inequalities and to dress the edges, as at this stage the ratio of the width to the thickness is great, and heavy side reduction is impossible.

ARRANGEMENT OF UNITS FOR BLOOMING MILL, BILLET MILL, AND SHEET-BAR MILL

The arrangement of the various units composing a blooming mill, billet mill, and sheet-bar mill differs in each plant, due to local requirements and conditions, proximity of other mills, available track service, etc. Nevertheless, such a mill properly laid down will realize certain minimum essentials:

The blooming mill must be provided with an independent outlet for its product through a bloom shear or slab shear to a bloom yard.

The continuous mill must be divided into two separate mills, and the distance separating them must be greater than the greatest length that the first mill will ever deliver, in order to afford a maximum of freedom in rolling and also in order to be able to divert the product at this point through a shear into a yard.

The first mill, being necessarily of heavy construction, preferably 24-inch nominal diameter, must have in its rolls all the working and dummy passes to produce the range of sections its program embraces. Roll changing in such a mill is too much of a burden to be assumed except in occasional emergency forced by breakage of rolls. All of these passes must be arranged in definite lines and must be fully equipped with guides, so that a bloom can be directed into any line by a switch in front of this mill.

The second mill must have a pass design which will render available all the desired small billet sections in a single set of rolls. In cases where both billets and sheet bar are produced, the mill must also have a set of sheet-bar rolls, which latter should preferably have their own set of housings, in order that the change from

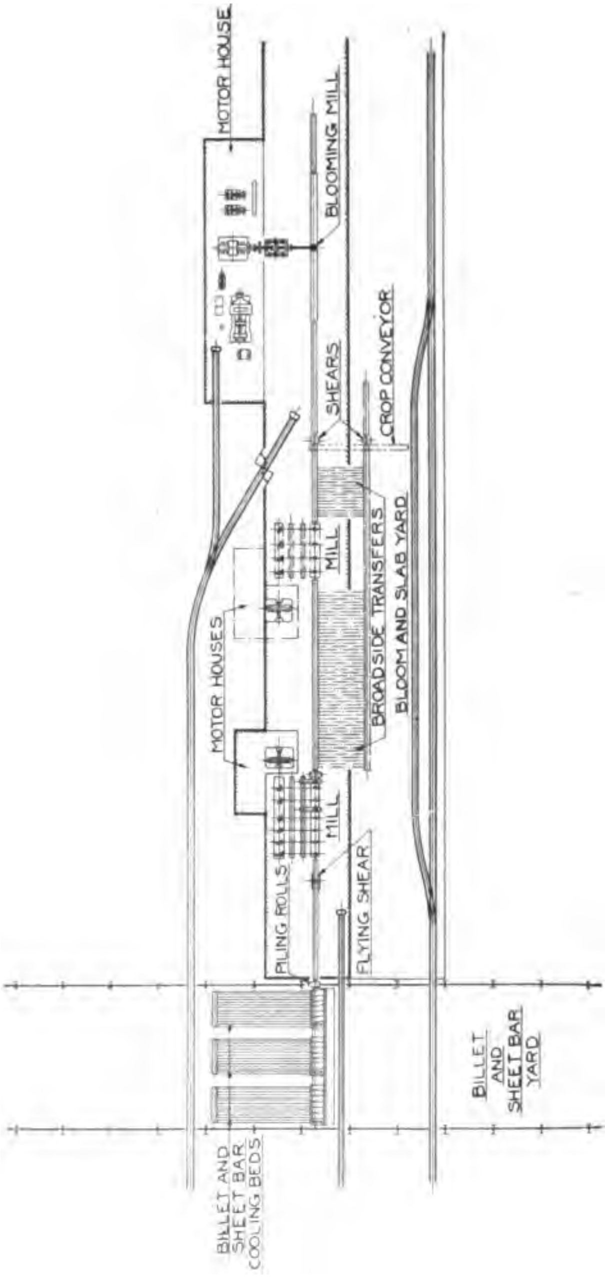


Fig. 2. Blooming Mill and Continuous Billet and Sheet-Bar Mill.

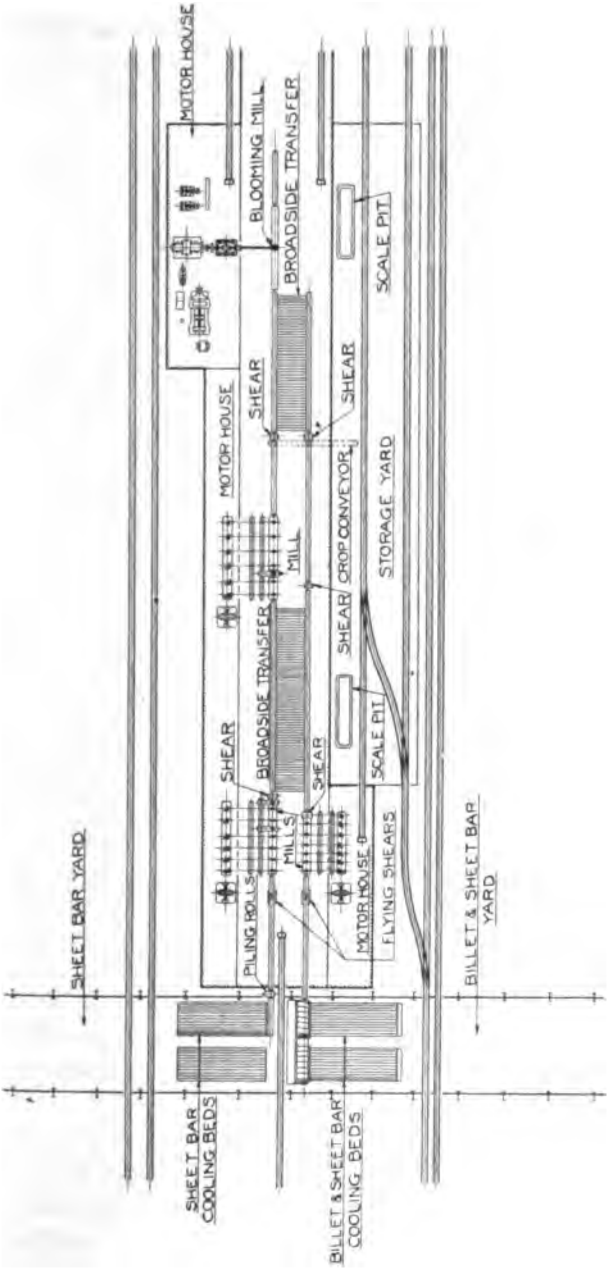


Fig. 3. Blooming Mill and Continuous Billet and Sheet-Bar Mill.

billets to sheet bar, and vice versa, may be made as expeditiously as possible. With a double equipment of housings, the rolls for billets can properly be longer than the short, stiff rolls that are required for accurate sheet-bar rolling.

In Fig. 2-6 are shown several plans of mill combinations for blooming, billet, and sheet-bar mills which satisfy these essential conditions. Each lay-out shows some particular feature of general arrangement which would be difficult to describe without the aid of illustrations.

Fig. 2 shows an arrangement of a blooming mill and continuous billet and sheet-bar mill. Blooms and slabs rolled by the blooming mill can be diverted by a broadside transfer through a heavy shear into a bloom yard. In this installation, the billet and sheet-bar mill is direct connected to an electric motor; and this motor is placed under the crane in the main building, but in a separate motor room, while the control and switchboard are in a lean-to. Provision is made, as shown in dotted lines, for the future installation of a continuous roughing mill and a broadside transfer for carrying out heavier billets through the building columns into the bloom yard, for which purpose a girder of sufficient length has already been provided in the building.

Fig. 3 shows a blooming mill and a continuous billet and sheet-bar mill in which the bevel-gear, transmission and electric motors are in a lean-to of the main building, thus permitting the broadside transfers for blooms and for the product of the first continuous mill to be kept inside of the main building. Provision is made for the installation of a second 18-inch mill with a flying shear and cooling beds. When this is installed, one mill will be permanently for sheet bar, while the other will always make billets. The roughing mill over-feeds the 18-inch mill sufficiently to support both of them. An edging mill of heavy construction is provided in the continuous roughing mill to afford flexibility in rolling a multiplicity of slab widths.

Fig. 4 shows a combination of a blooming mill, 24-inch continuous roughing mill, and 18-inch continuous sheet-bar and billet mill in which high-speed motors drive the continuous mills through reducing gears. In this mill, a shear is introduced ap-

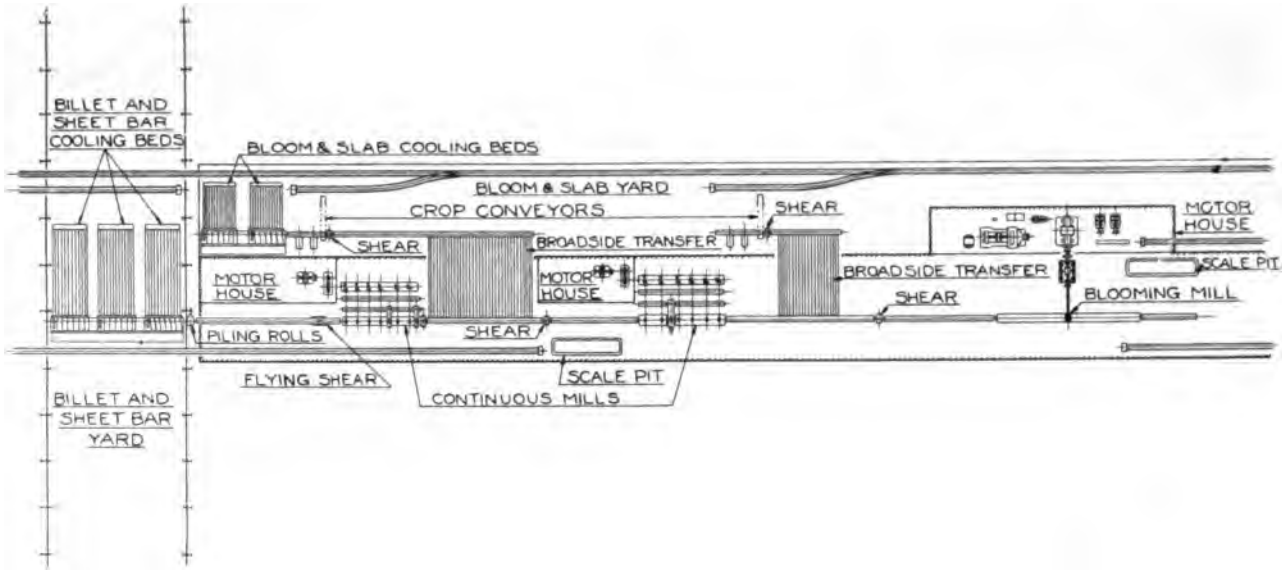


Fig. 4. Combination of Blooming Mill, Continuous Roughing Mill, and Continuous Billet and Sheet-Bar Mill.

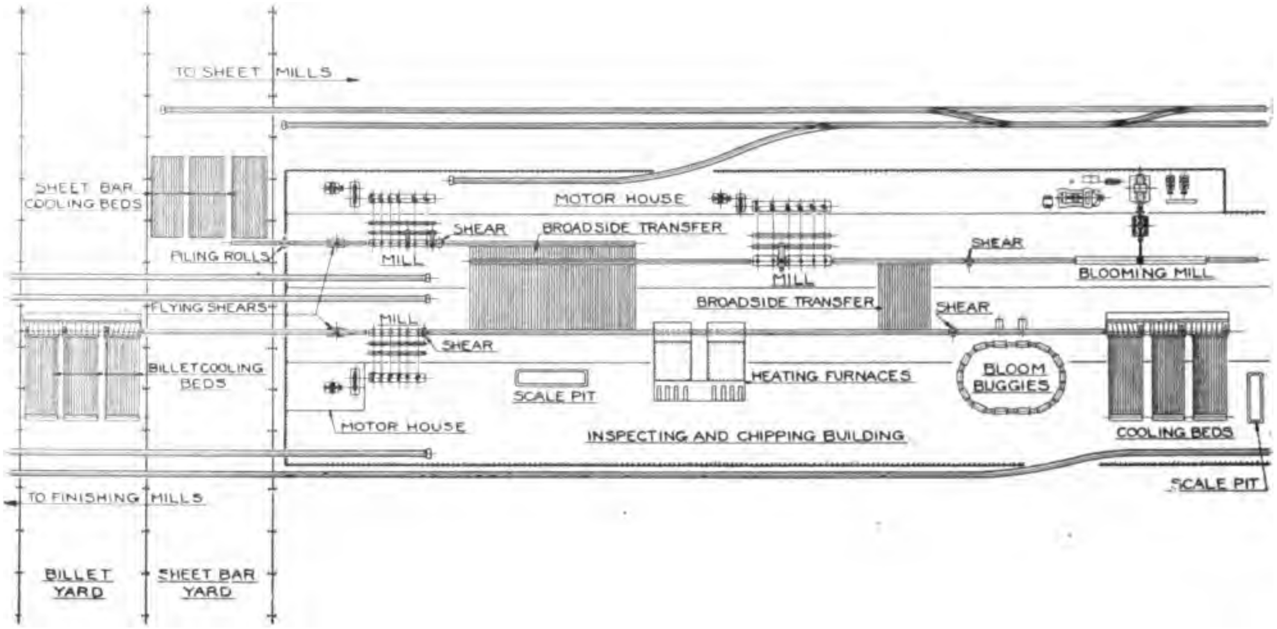


Fig. 5. Blooming Mill, Billet Mill, and Sheet-Bar Mill Arranged for Special Conditions.

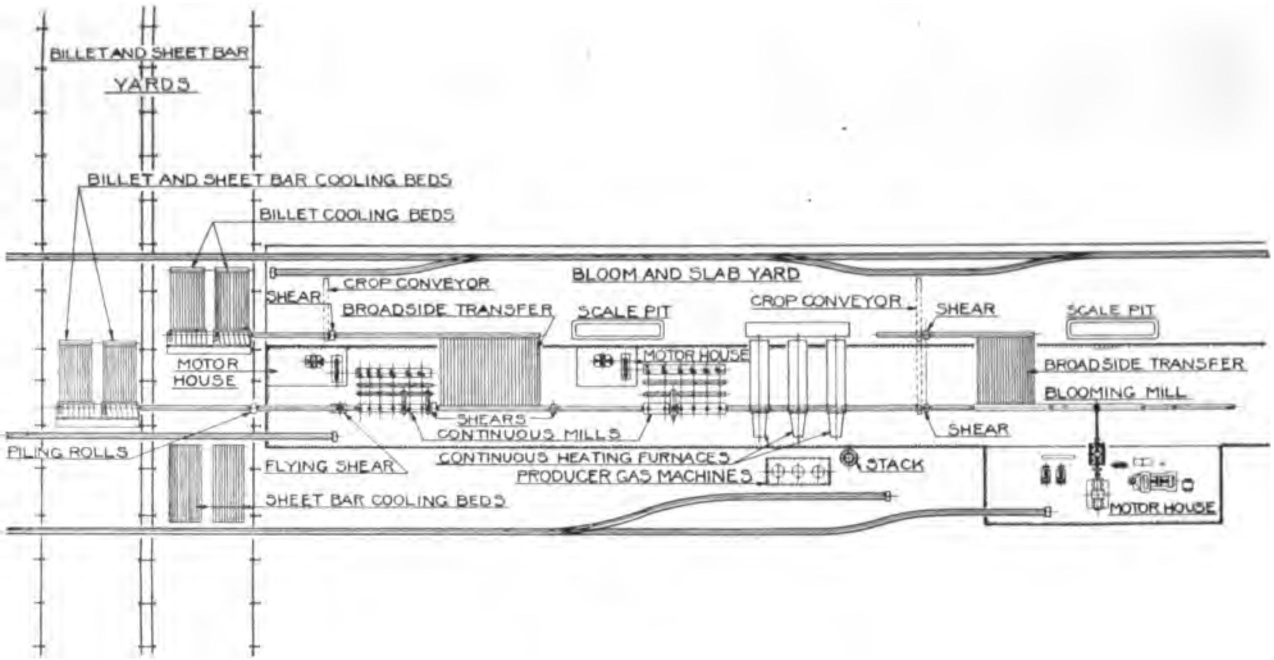


Fig. 6. Continuous Mills, and Furnaces for Reheating Slabs.

proximately midway in the connecting table between the two continuous mills to part the billet so that it can be diverted into the adjoining yard over a narrow broadside transfer. When steel is not so diverted, it is passed on to the 18-inch mill in a single length. This arrangement has the advantage of leaving the working side of the mill entirely unobstructed and of requiring a girder of only moderate length to pass the broadside transfer into the billet yard.

Fig. 5 shows an arrangement of blooming mill and billet and sheet-bar mills for special conditions. In addition to the features previously emphasized, an inspection and chipping building runs parallel to the main building of the mill. Two furnaces, capable of taking 30-foot billets after they have been chipped, deliver them heated to the 18-inch billet mill. This provision is made to care for alloy steel where it is advisable to remove surface imperfections before the steel is reduced to minimum section.

There are some widths of skelp, which are too wide for the continuous skelp mill and too narrow for the universal plate mill, which can properly be rolled on continuous mills, provided the temperature can be maintained to secure the skelp thicknesses. Fig. 6 shows continuous furnaces for reheating slabs from 8 to 16 inches in width for rolling into skelp.

Fig. 7 shows a typical arrangement of billet and sheet-bar passes. The sheet-bar reductions are made on plain cylindrical rolls with the width controlled by vertical edging rolls.

WIRE-ROD MILLS

General. I chose to speak of billet and sheet-bar mills first, because they are the first continuous mills to work upon the steel after the cast ingot commences to undergo mechanical treatment. The rod mill, however, was the first of the continuous mill family to be put into operation—not because wire rod presents the easiest continuous rolling problem, but because it was in its production that conditions were first found which justified a specialty mill. These conditions were a large demand for a single size and section, and a premium on length. George Bedson showed great

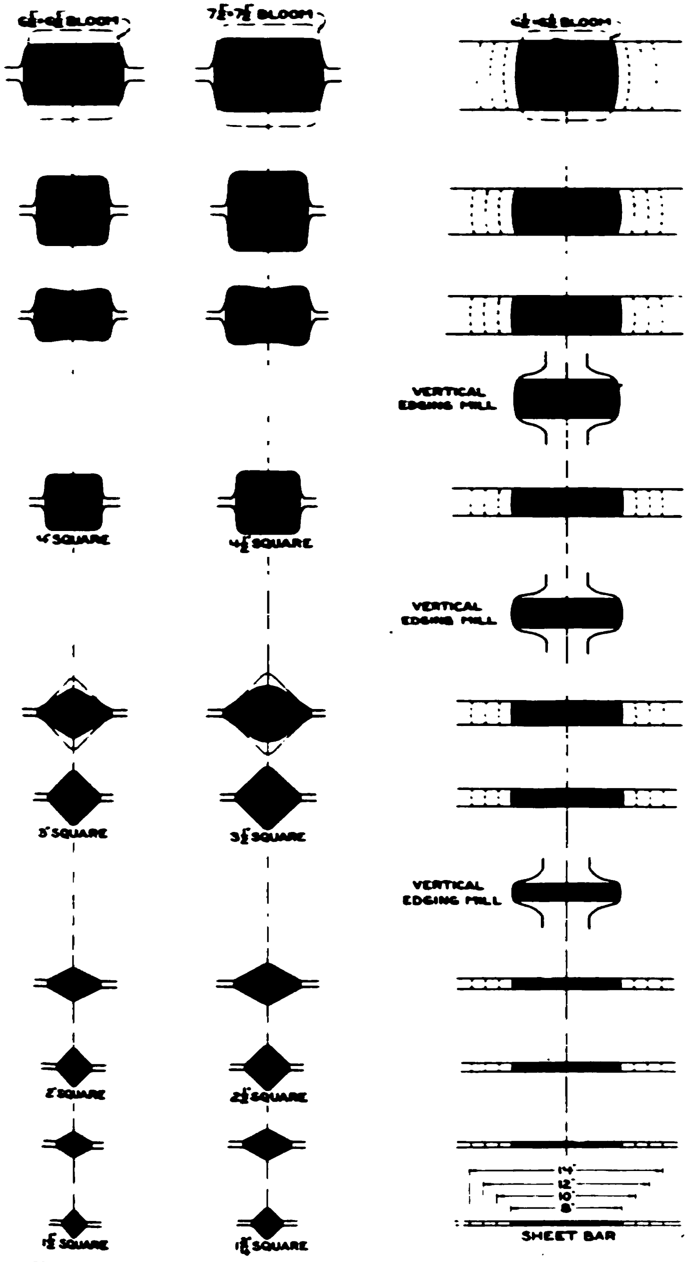


Fig. 7. Arrangement of Passes for Billet and Sheet Bar.

courage in putting into practice such an advanced form of rolling on such a difficult product.

Any discussion of rod rolling almost necessarily involves a comparison of two mills which took form almost simultaneously. These are the continuous mill and the Belgian, or looping, mill both of which are in use to-day.

The continuous rod mill has changed but little in principle since its inception. The improvements made in it have been largely in details and in the collateral auxiliaries, such as heating furnaces, shears for cropping in process, and equipment for coiling, cooling, and disposing of the finished rod. In the looping mill, on the other hand, there have been a gradual evolution and a decided tendency to approach continuous rolling.

Let us stop for a moment to note the development of the looping mill and the stages through which it passed. It had, in early form, an 18-inch or 16-inch three-high, hand roughing stand which reduced a four-inch by four-inch billet to a square approximately 1 3/16 inches in section. This square was next passed three times through an intermediate roughing mill, running at higher speed. Then the material passed to a finishing mill arranged in two trains, each having four pairs of rolls and each train driven at a different speed. The rolls in each train were progressively increased in diameter to reduce the extent of the loops. The loop between the two groups was of course under full control and did not grow appreciably, but between stands in the same group the growth of the loop to large dimensions could be controlled only slightly by manipulating the roll diameters. This increase in roll diameters, moreover, gave a poorly lined up transmission.

Disregarding the auxiliary equipment and confining our attention to changes affecting the rolling process, we find that the first significant improvement in the looping mill was borrowed from contemporary merchant-mill practice. The three-high roughing stands were abandoned in favor of a continuous roughing train.

The next significant change was the division of the finishing mill into three trains, in order that there might be more points of loop control than obtained in two-train construction.

Continuous rolling is usually regarded as a process in which the rolls are arranged in tandem, and the steel passes from one pair of rolls to another through a short intervening space. The reductions are performed simultaneously by the several pairs of rolls, each successive pair driven at an increasing speed to care for the elongation. This, in my opinion, should be termed "straight continuous rolling" and should not be granted the general definition of "continuous rolling." I regard continuous rolling, in its broadest sense, as that form of rolling in which the material, in the process of reduction, passes but once through each pair of rolls and where the speeds of the rolls are so related that they are proportional to the elongation taking place. Under this definition, the rolls need not be arranged in tandem, but may be so placed that a loop is formed. If this definition is accepted, then, in justice to the continuous principle of rolling, it must be said that the loooping mills, by the splitting up of the trains into smaller groups whose speeds are adjusted for loop control, are constantly approaching the continuous mill in principle.

In justice to the looping mill, on the other hand, it must be said that recent continuous rod mills have been divided into groups with intervening 180-degree loops to secure some of the freedom and flexibility which the looping mills possess. The continuous principle, however, is preserved, because the speed relation between groups is maintained for full control of loops.

The inevitable result of long loops in Belgian mills, together with their necessarily slower finishing speed, governed by the limit of manual skill, is serious loss of temperature. This loss of temperature is reflected in higher power consumption to the extent of about 35 per cent. Finishing temperatures can be kept within reasonable bounds only by rolling small bundles in which, since crop losses are the same per bundle, the yield is from 1.5 to 2 per cent. smaller than with 300-pound bundles.

This reference to looping mills has been made for purposes of comparison—not because these mills are a part of the subject matter of this paper, but because both forms of rolling are practised, and undoubtedly both are of interest in discussing rod rolling.

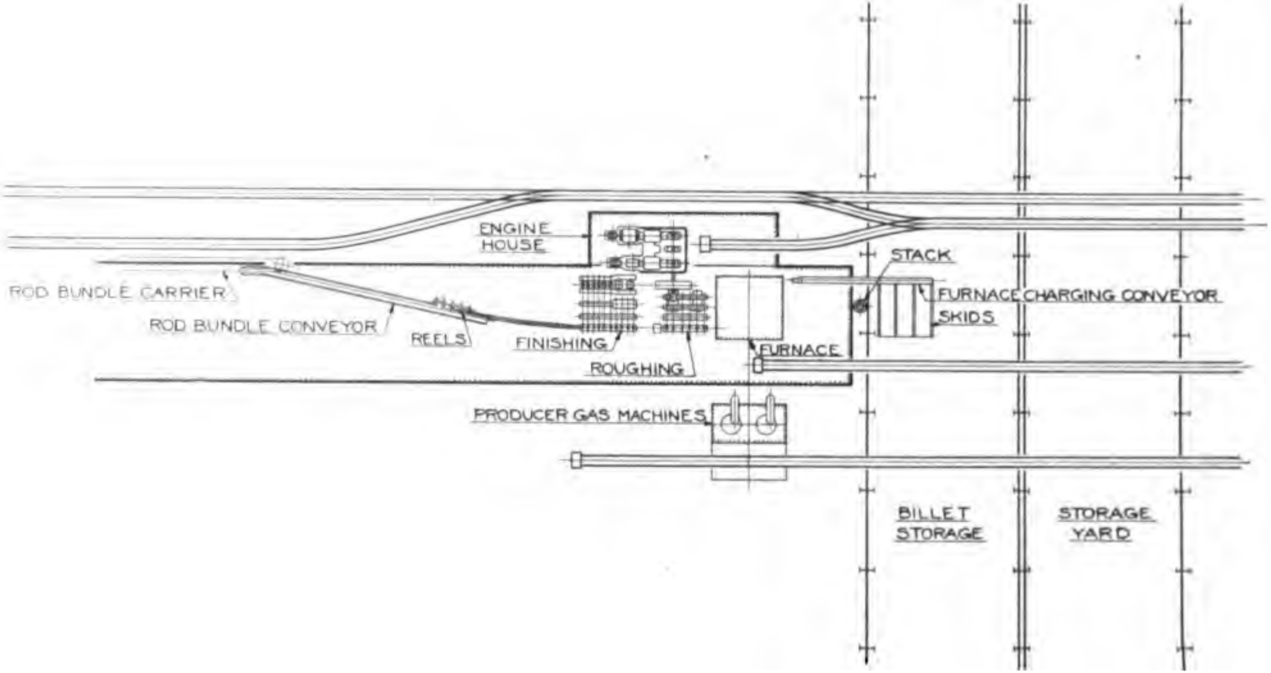


Fig. 8. Straight Continuous Wire-Rod Mill.

Continuous Rod Mills. The straight continuous rod mill shown in Fig. 8 has been brought to a high state of development by advanced details of construction and the introduction of very efficient auxiliaries. It usually consists of 16 stands of two-high rolls divided into two groups. The first group consists of six stands of rolls, the first pair located immediately in front of the furnace. The furnace, of the side-discharge type, feeds uniformly heated 30-foot billets, 1.75 inches square, to the first stand; and the entire installation is so compact that when the product begins to come onto the reels, two thirds of the billet is still in the furnace being heated. The second group consists of 10 stands of rolls, and is separated from the first group by a space of about 20 feet in which a flying shear is installed. This flying shear crops the front end of each bar as it issues from No. 6 stand, so that a clean end is presented to the finishing mill where the high-speed rolling begins. An additional function of the gap between the two groups of mills is to provide a space where a little slack can be formed. This insures absence of tension in the material at this point and makes possible the adjustment of the passes of the finishing mill without corresponding adjustment of the roughing mill.

The roll passes in the finishing mill require accurate turning and skilful adjustment to secure the best results. If excessive tension develops at any point in the mill, finned ends will result. The factors in this equation under control of the operating crew are the accurate turning of the grooves and the proper choice of roll diameters for the various stands. It is surprising, in view of the precision that is required, what good rods the straight continuous mill is producing and how skilful the rollers have become in detecting the smallest irregularities.

The skill of the roller and his crew is a large factor in the successful operation of straight continuous rod mills. If we stop to consider that two strands of rod are rolled simultaneously, with all that this implies in the way of delicate adjustment of rolls and guides, and that the finishing speed is 3200 feet a minute, it will be clear that in the rod-mill crew there is opportunity for team work of the high order of major league baseball.

Recent installations of continuous rod mills have taken a form,

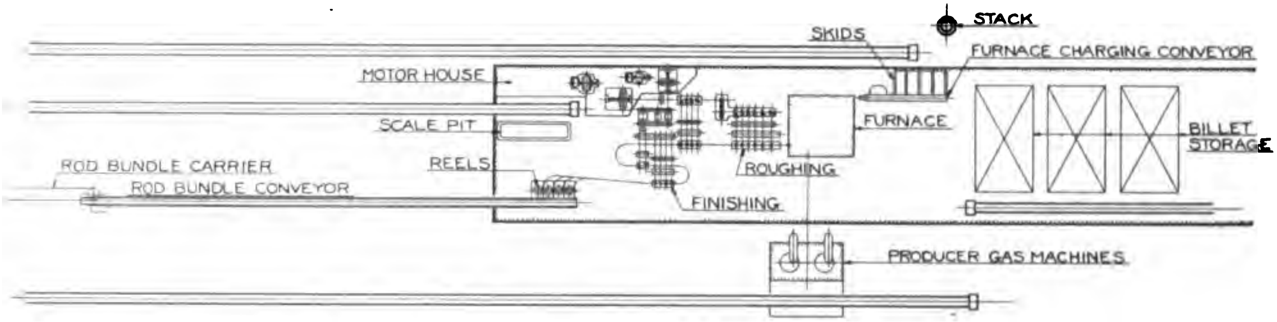


Fig. 9. Continuous Finishing Trains Arranged in Three Groups.

shown in Fig. 9, which makes the work of the roller easier and gives him additional freedom and flexibility. The continuous finishing mill is broken up into three groups connected by 180-degree repeaters. The groups are separately driven at correct speeds to prevent almost completely the growth of the loops after they are formed. The exposure of the steel on the looping floor is extremely short and is uniform for each unit of length of the rod, so that there is no difference in temperature between the first and last end of the rod in the finishing pass. This form of continuous rod mill has reduced the fin at the back end of the rod bundle to between 24 and 18 inches.

A continuous rod mill of this type gives a monthly production of slightly over 10,000 gross tons of No. 5 rod with a yield of 97 to 97.5 per cent., a fuel consumption of 127 pounds of coal, and a power consumption of 90 kilowatt-hours per ton of output.

MILLS FOR ROLLING FLAT FINISHED PRODUCTS

Under this classification come skelp, strip, hoop, and cotton-tie mills. Since the same problems are involved in each case, these mills may be treated as a single subject.

The rolls of such mills are, with few exceptions, of plain cylindrical form without grooving. The use of plain cylindrical rolls affords a maximum of flexibility in producing flats of a variety of widths. The width of the rolled product is controlled by means of vertical edging rolls; therefore, tongue and groove passes are not necessary.

The use of vertical rolls, with center which can be adjusted, avoids the difficulties encountered in continuous trains in edging flats in horizontal rolls with fixed centers. The delivery speed of an edging roll is substantially the speed at the bottom of the groove. The grooves in a horizontal roll must necessarily be of varying depth for the varying widths, and obviously there is no common delivery speed for all widths of flats to which drafts can be related. As a consequence, the draft becomes absurdly light for wide flats and impossibly heavy for narrow flats. This is entirely avoided when, with a fixed groove depth, the centers of vertical rolls can be adjusted for the variation in the width of flats.

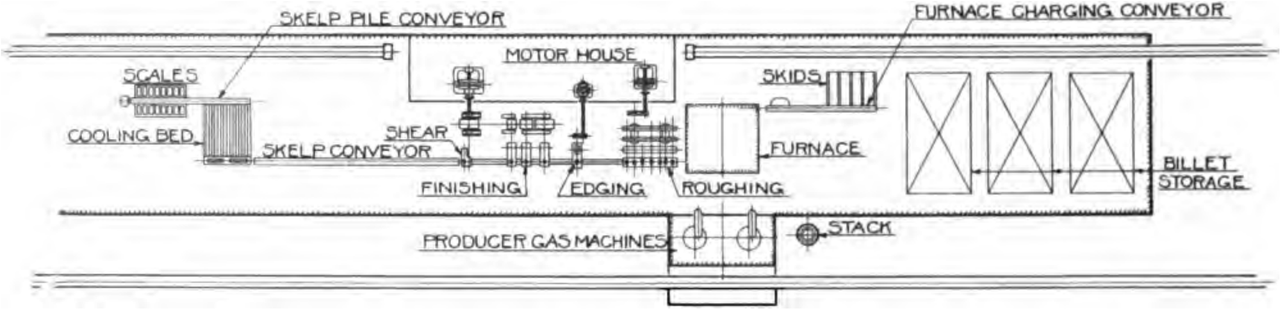


Fig. 10. Continuous Skelp Mill.

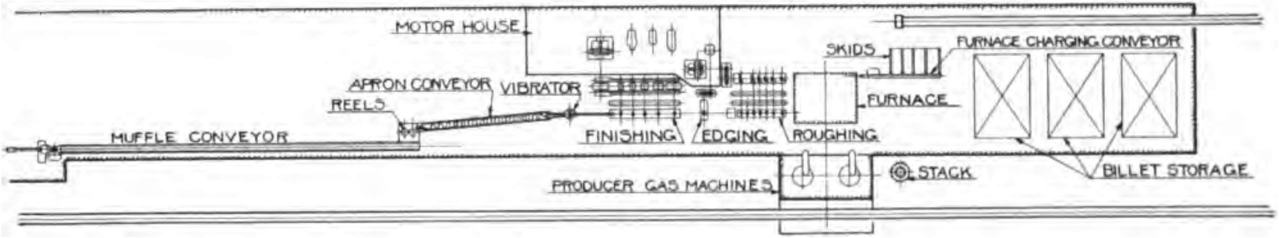


Fig. 11. Continuous Hoop Mill.

Billets for conversion into flat products in continuous mills are usually of slab section, the width varying to suit the product. The thickness of the slabs is maintained around 1.75 and two inches. When narrow flats are to be produced, 1.75 and two-inch square billets are used; and for the very narrowest flats, such as cotton-tie and hoop, these billets are reduced to smaller squares in grooved passes before the flatting process begins.

The roll stands of continuous flat mills are arranged in straight continuity, and are divided into roughing, intermediate, and finishing mills, each of which is driven by a separate motor. The advent of adjustable-speed motors having a wide range of speeds has permitted a degree of flexibility that is highly desirable in flat rolling. Vertical looping is induced immediately after the bar leaves the roughing rolls. In this way, the necessary freedom to obtain accurate sections from end to end is secured. In all cases, the first stand of the roughing mill is placed immediately adjacent to the discharge door of the heating furnace, so that the temperature of the entire rolled length may be maintained uniform.

Flat mills differ from one another chiefly in their size, the total number of stands, and in the disposal of the product. The principles involved are identical for all their products. Two types are illustrated in Fig. 10-11.

Skelp must be cut into lengths not exceeding 22 feet; consequently, skelp, after it leaves the finishing rolls, passes through an automatic flying shear which cuts it into the desired lengths. These lengths are collected mechanically into piles on the cooling bed, which piles, each representing the product of one or two billets, are advanced across the bed to the bundlers and weight scales. A 10-inch skelp mill, consisting of eight pairs of horizontal rolls and two pairs of vertical rolls, one pair driven by an independent motor, produces skelp from 1⅝ inches up to eight inches in width and makes from 12,000 to 14,000 tons of finished product per month.

Strip steel, hoop, and cotton tie are customarily finished in coils. These coils are formed on ribbon reels, two of which are usually sufficient to receive the product of a mill.

After leaving the last stand of rolls, the material passes through a vibrator. A vibrator is a machine which lays the finished flat in serpentine form upon a slowly advancing conveyor, where it stands on edge until its front end is picked up and entered into one of the reels by hand. The reel runs at a considerably greater speed than the mill, so that there is ample time for starting, coiling, and discharging the bundle before the next strip is due.

Straight continuous rolling at high speed brings the steel to the finishing pass hot, with the result that thin gages can be produced. Each unit length of billet starts at the same temperature and undergoes each reduction at exactly the same period in the rolling cycle. Because of these conditions, the finished piece is of absolutely uniform gage and temper from end to end. These conditions are in striking contrast to those which obtain in hand strip mills, the product of which necessarily varies in gage, due to the amount of exposure to cooling influences.

MERCHANT MILLS

Very few merchant mills can be called continuous, even under the broad definition given earlier in the paper.

Merchant bar, under which classification comes all hot-rolled steel that is sold from warehouses direct to the retail trade, is a finished product and must be accurate in size and section. Consequently, merchant bar must be finished in passes that operate entirely independent of one another, and pure continuous rolling must be limited to the earlier stages of reduction.

While merchant mills cannot be made continuous in the full sense of the term, they may be so designed that they are substantially continuous in principle, in that the material passes but once through each stand of rolls and the speeds of these stands are related with various degrees of precision for maintaining continuous speed progression. There are instances of merchant mills where the finishing passes are so arranged that the growth or shrinkage of floor loops is negligible. This has become possible as single engines or motors driving the entire mill have been supplanted by several motors of adjustable-speed characteristics, each driving variously arranged groups of rolls.

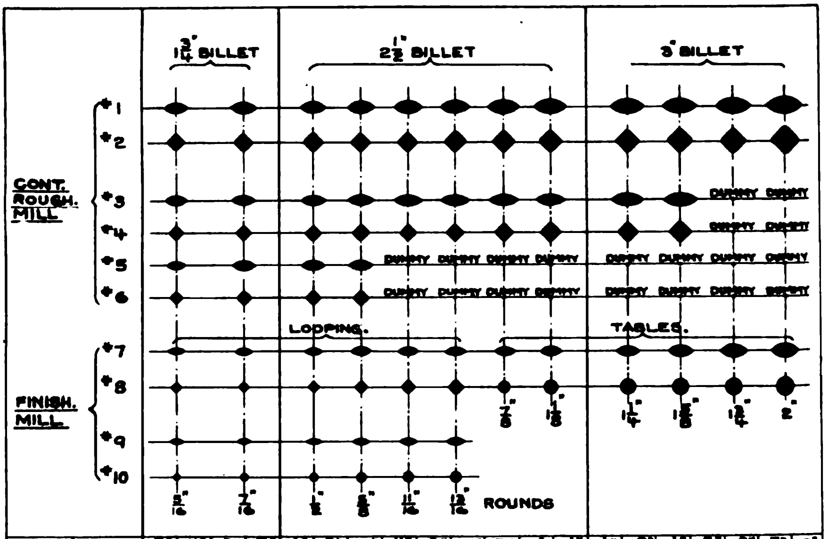
The designing of a contemplated merchant-mill installation is almost invariably hampered by the fact that a wider range of sizes is specified than can be secured to best advantage from one mill. This condition is a real handicap and results in sacrifices which ultimately are found to have been unnecessary, since extreme sizes at both ends of the scale gradually disappear from the rolling schedule as the mill is getting into its stride. Continuous merchant mills do remarkable work from the standpoint of economy and tonnage. It is, therefore, a natural consequence that each mill settles down sooner or later to its own economical range of production. This seems to be one of the lessons which experience alone can teach, and the pity is that this cannot more often be made a premise of the original design.

As the total number of passes is fixed by the number of stands in the entire mill, small sections must be rolled from small billets, and large sections from large billets. In this respect, continuous merchant mills differ fundamentally from hand mills. In the latter, since the number of stands bears no fixed relation to the number of passes that are taken, in that, frequently, several passes are made in the same stand, a widely varying range of sizes may be finished from the same billet section.

Another very important reason for using billets of different sizes in continuous merchant mills relates to the matter of keeping the cooling-bed surface filled while using a billet of uniform length. Uniform billet lengths are essential to good practice in billet yards and heating furnaces. In continuous merchant mills, long sections, accurate from end to end, can be secured. Since the billet length is fixed, whether it be 30 feet or some other length, change in finished section brings with it change in finished length. This means that, in order to use the cooling-bed length to best advantage, the cross-section of the billets must be increased with the finished section.

A given area of cooling-bed surface has a definite cooling capacity. Bars of larger section finish at higher temperature and usually have less radiating surface to liberate their stored heat. It is, therefore, necessary to roll them in long sections in order to give them the advantage of the greatest cooling area on a given bed.

It is, of course, true that, in order to fill the bed to the same degree with every finished section, there would be required as many billet sizes as there were finished sizes. This is manifestly impractical, and a compromise must be made. The rolling practice is therefore based on a supply of billets in such progressive sizes as can be conveniently obtained. By a judicious choice of billet section, and the division of the billet into multiples, every finished section can be put upon the bed in a length which will keep the average efficiency of the bed very high.



ROUND	DIA.	5/16"	11/32"	3/8"	7/16"	1/2"	9/16"	5/8"	11/16"	3/4"	13/16"	7/8"	1"	1⅛"	1¼"	1⅜"	1½"	1⅝"	1¾"	1⅞"	2"
	WT. PER FT.	.261		.3757	.5114	.668	.8454	1.0437	1.262	1.503	1.764	2.046	2.672	3.382	4.175	5.052	6.012	7.055	[illegible]	[illegible]	10.69
BILLET	SIZE	1¾"				2½"									3"						
	WT. 30 FT.	308 LBS.					629 LBS.								906 LBS.						
	PIECES	4	3	3	2	3	3	2	2	2	2	1	1	1	1	1	1	1	1	1	1
PASSES	ROUGHING	6	6	6	6	6	6	6	4	4	4	4	4	4	4	4	4	4	2	2	2
	FINISHING	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2	2	2	2	2	2
	TOTAL	10	10	10	10	10	10	10	8	8	8	6	6	6	6	6	6	6	4	4	4
FIN. LENGTH	TOTAL	1180	975	820	601	940	745	600	498	418	356	306	235	186	217	180	151	128	111	97	85
	ON BED	295	325	273	300	313	248	300	249	209	178	306	235	186	217	180	151	128	111	97	85

Fig. 12 Preliminary Study of Merchant Mill For Rounds.

From the foregoing, it is obvious that the selection of a cooling-bed length for a given billet length must be made very carefully. For purposes of illustration, I submit a preliminary study (Fig. 12-13) recently made in considering a merchant mill for the production of rounds from 5/16 inch to two inches in diameter. This is merely a preliminary survey and is given here to show the scope of the analysis that is required to determine the suitable billet sections, the number of multiples into which they should be cut, and the degree to which they will fill the cooling bed. I consider the range aimed at in this study entirely too great for a single mill.

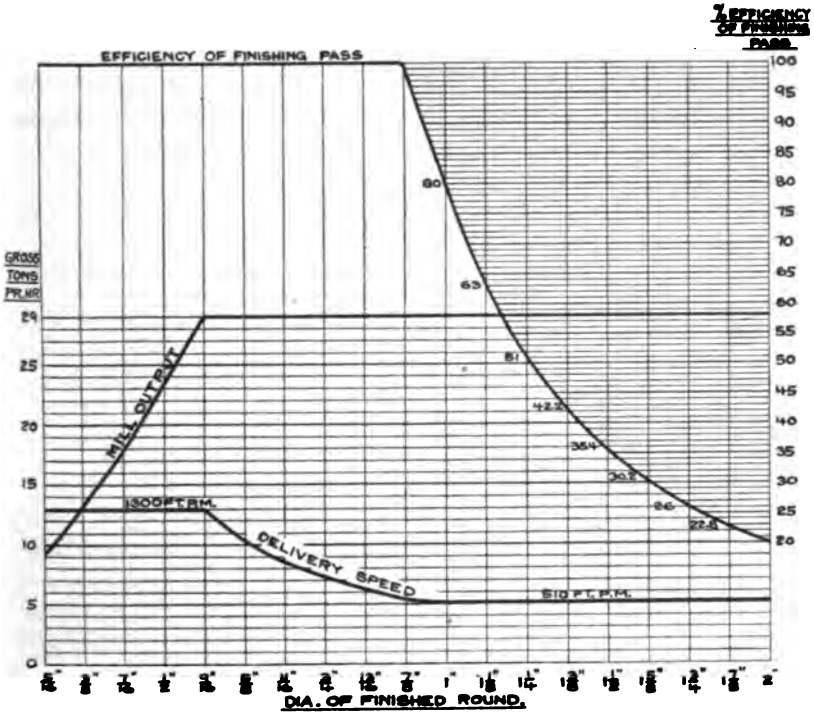


Fig. 13. Production Study Based on Fig. 12.

Continuous merchant mills can be classified according to the manner in which the product is manipulated in the finishing mill. By the steel industry, no specific name has been given to merchant mills of different types, but I believe if we call one a "looping

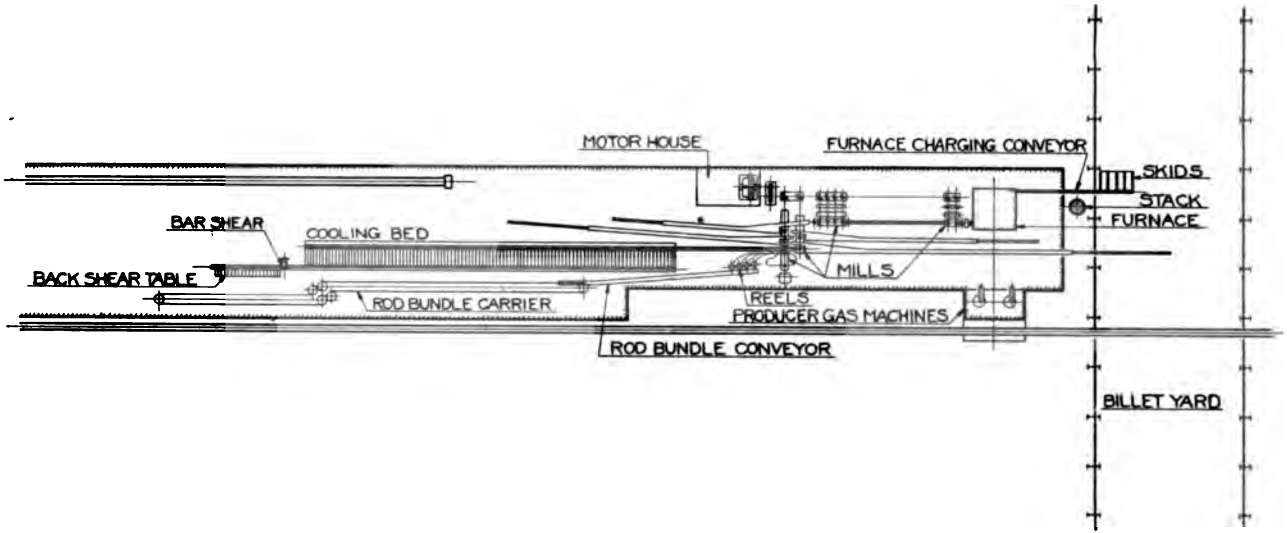


Fig. 14. George "Staggered Duo Mill."

merchant mill" and the other a "table merchant mill" we shall not fail to make our meaning clear.

The "looping merchant mill" is obviously a mill of small nominal diameter for rolling smaller sections. It uses 30-foot billets ranging from 1.5 to 2.25 inches, and possibly 2.5 inches square. The division of the total number of passes between the continuous roughing and looping mills permits of a great number of combinations. Each particular grouping is, of course, predicated upon the purpose of the mill. This subject was very thoroughly presented by Jerome R. George in a paper on "Merchant Rolling Mills," read before the American Iron and Steel Institute.*

The continuous "table merchant mill" has finishing trains of 12-inch nominal diameter, and upwards, and rolls the larger merchant bar. It may have many different groupings of its rolls. One design of mill of the table type recently brought out—which is called the "staggered duo mill," because the roll stands are of two-high construction and are staggered—is illustrated in Fig. 14–15.

Fig. 14 shows a George "staggered duo merchant mill," fed by a 30-foot continuous heating furnace, and a six-stand, 14-inch continuous roughing mill divided into two parts. An auxiliary eight-inch mill is provided to be used until such time as conditions warrant the installation of a smaller mill, when the undesirable smaller sizes will not be a part of the schedule of this heavy mill. The "skew Y tables" are used only for sizes that cannot be turned in. At all other times the mill is used as a looping mill, and provision is made for the loops to run over and between the tables.

Fig. 15 shows a George "staggered duo mill," fed by end-discharge furnaces, and an interrupted continuous 16-inch roughing train. This mill is intended for rounds from 1 to 2.5 inches in diameter and uses, four-, five-, and six-inch square billets in 11-foot lengths. It also rolls flats and angles of equivalent sizes.

As built in two particular instances, the rolls are of 12-inch nominal diameter; and the mill is intended to roll rounds from ⅞ inch to 2.5 inches, and equivalent sections of squares, flats, and

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*Year book of the American Iron and Steel Institute, 1915, pp. 122-142.

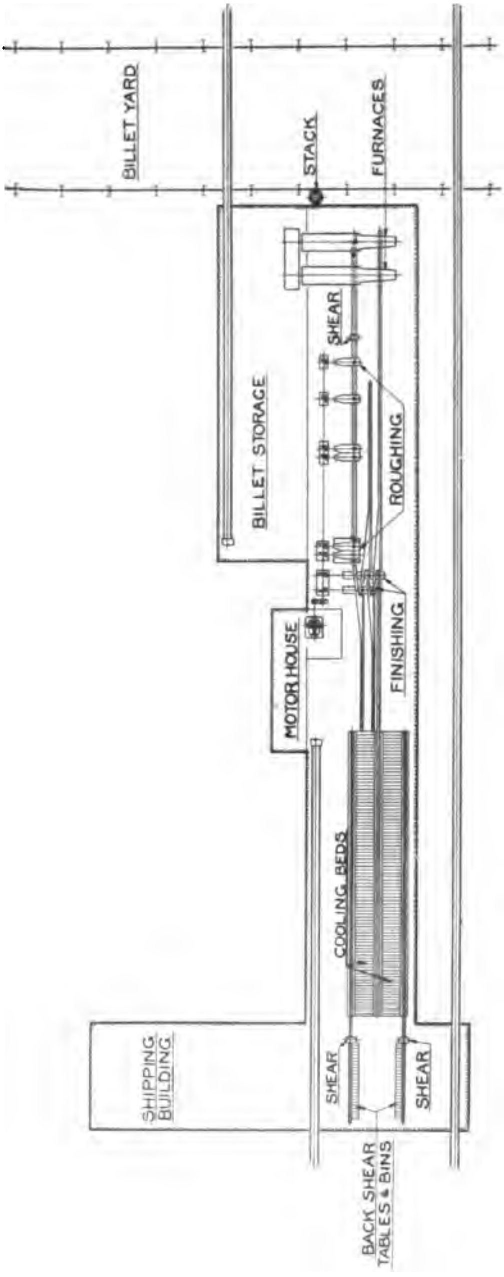

Fig. 15 George "Staggered Duo Mill" for Rounds, Flats and Angles.

angles. One such mill is confining itself entirely to angles up to three inches. It has proven very suitable for this purpose.

A peculiar feature of the staggered duo mill is the short distance between rolls, which the staggered arrangement of the roll stands permits and which, in turn, obviates the necessity for using a broadside transfer. Instead, a special, single table with skew rolls is employed. The end of the table near the rolls is forked, and, because of this, it has become known as a "skew Y table."

The last stand of the roughing rolls of staggered duo mills is connected with the first stand of the finishing mill by a reversing "Y" table with skew rolls in which the skew determines the position of the bar on the table, making it hug one or the other side according to the direction in which the bar travels.

Thus, when a bar is being received, the table rolls are run forward with the bar, and the bar follows the side guard nearest the delivery pass. After the entire length has been delivered, the table rolls are reversed. This makes the bar move in the opposite direction and, at the same time, move broadside across the table to the opposite side guard, which in connection with suitable switches enters it into the next pass. Just as soon as the mill roll has taken control of the bar, the table may be run in the direction for receiving the next bar. Similar tables of progressively greater length connect the remaining passes of the mill.

CONCLUSION

Considerations entering into the question of employing a continuous mill resolve themselves into balancing low operating costs and high yield against the initial investment. The initial cost always looks formidable, but it need not. Overhead charges may be high in total; but when the divisor—annual production—is applied, the overhead charges per ton are found to be no greater than those on simpler mills. Thus, consideration of overhead investment is eliminated, and the lower operating cost and higher yield of the continuous mill are net gain.

In this paper, continuous rolling has been described as it applies to the production of small billets, sheet bar, flat finished products, wire rod, and merchant bar—these being the products which, so far, have justified the investment in continuous mills.

As to the future of the continuous mill, we may say that we know of no way to judge, other than by the past. Whenever, in the past 40 years, the demand for any product has reached such proportions that a single organization could market the output of a continuous mill, a continuous mill for that product has made its appearance.

Those who are most closely identified with continuous-mill development know that its possibilities have scarcely begun to be realized. They do not hesitate to predict that, whenever a specialty in hot-rolled steel reaches the required point of standardization and demand, a continuous mill for that specialty will be forthcoming and that its appearance will mark a substantial reduction in the cost of that specialty.

DISCUSSION

Prof. W. Trinks:* I don't know so very much about rolling mills, but I was quite surprised at the conclusion stated at the end of the paper. Mr. Sheperdson was kind enough to tell us that whenever there is sufficient demand for a standardized product, the continuous mill will be there to take care of it. There can be no question that there is sufficient demand for standardized steel sheets, and I would like to ask what Mr. Sheperdson has to say in regard to continuous sheet rolling mills.

Mr. J. W. Sheperdson: To answer your question regarding the prospect of rolling sheets continuously is not easy, and I believe my closing statement in the paper that continuous mills will be forthcoming whenever there is a demand sufficiently great in any product must be retracted, unless it be qualified by, "with the exception of sheets."

Studies have been made for producing skelp up to 24 and 28 inches in width in a continuous mill. The sum total of the peak power requirements runs up into such figures that, so far, no one has been willing to face such demands upon the power system. Power input is a function of torque and speed. The torque is high because the section is wide and thin; the speed must be high in order to be able to finish thin sections before they have cooled to call for too high a torque. Both these factors tend to make the power peak very high for wide, thin, sections.

Mr. O. Needham:† I am connected with an electric company, and, therefore, am particularly interested in the power end of the mill—in other words, the driving units. We are frequently called upon to make calculations and recommendations as to the size of motor required to drive a certain mill, and I was, therefore, very much interested in Mr. Sheperdson's curve showing the limitations of mill capacity, which is a very important consideration when it comes to specifying the size of motor required to drive a mill. Naturally, in making a recommendation as to the motor size, it is necessary to know what is going to be the limit of the possible tonnage which can be turned out in that mill. Continuous mills are comparatively easy to calculate as compared with other types, for the reason that a definite cycle can be laid down for a continuous mill. The exact sequence of passes can be predetermined, and, consequently, the load curve when the reductions are known. This is not so easy to do with other types of mill, due to the fact that the material is handled by catchers at various places, and there are many opportunities for delay, so that possibly no two pieces follow each other through the mill in exactly the same manner.

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*Professor of Mechanical Engineering, Carnegie Institute of Technology, Pittsburgh.

†General Engineer, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

It appears that when rolling the smaller sections on a continuous mill, it is possible to keep the finishing pass full a large percentage of the time. However, on the larger sections, this would mean an enormous furnace capacity, so that the limit of tonnage would be the furnace capacity.

Mr. J. W. Sheperdson: The problem of determining the power peak of continuous mills is predicated upon the aggregate load, and usually this is represented by a mill full of steel, rolling its hardest section. Usually, also, the root mean square of the load can be arrived at accurately, and I believe it is a fair statement that there have been fewer undersize and oversize motor applications with continuous mills than (owing to the nature of the problem) has been the case with other types of mills where the peak and the root mean square of the load can be computed for a set of given conditions, but where these conditions may or may not be the true criteria over the life of the mill.

Prof. W. Trinks: I should like to ask another question. I have seen a good many modern continuous mills, and I have been impressed very much by the wonderful advance in the state of the art made by the Morgan Construction Company. I have been telling my students that they are the inventors of the modern continuous rolling mill, and I am very much surprised to learn that they are not. They are, however, as much the inventors of the continuous mill as James Watt was the inventor of the steam engine.

When it comes to the furnaces which go with these mills, you nearly always hear it said that "this is a fine mill, but the furnace is too small." Almost invariably, when a continuous mill has been installed by the Morgan Construction Company, there comes a time when the owners become dissatisfied with the output of the furnace, and want to know what they can do to increase its capacity. Therefore, I should like to hear why it is that these furnaces are so limited in capacity, or whether, if they were made larger, they would be too large for some of the sizes rolled by the mill.

MR. J. W. SHEPERDSON: The capacity of any heating furnace must have a limit somewhere. Suppose heating furnaces had twice their capacities, there would still be a limit. At the time of the development of continuous rolling mills, it was necessary to determine what heating capacity would best suit the average requirements, as, obviously, a furnace with too great a capacity would be uneconomical from the standpoint of fuel consumption and scale loss. The experience over a long period of very useful life of practically all continuous mills leaves very little to regret. Where markets have been formed for the upper range of output of a given mill, instances of lack of balance seem to exist, with the result that the furnace is called upon to support a mill capable of turning out a tonnage greatly in excess of the average presupposed conditions for which it was built. Such mills require new furnaces of adequate capacity.

MR. F. C. BIGGERT, JR.:* One point in this paper struck me very forcibly, and that was Mr. Sheperdson's remark in regard to the range of products rolled on various mills of their design. I have been interested in the design of mills other than continuous mills—that is, the usual run of structural, plate, and merchant mills—and in selling this class of equipment, we have frequently been asked to cover too great a range of sizes. It sometimes seems as though the purchaser would like to roll everything from a wire rod to a 24-inch beam on the same mill. This is the natural tendency of the purchaser who feels that he is investing a large amount of money, is more or less doubtful as to his market, and consequently, is anxious to cover as wide a range as possible.

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*President, United Engineering & Foundry Co., Pittsburgh.

Mr. Sheperdson's statement that he urges prospective purchasers to limit their range of sizes on any given mill as far as possible, is very well taken. As engineers, I think we ought to make an effort to counteract this tendency to cover too wide a range. When a mill is designed to produce a wide range of products, there are inevitably certain compromise arrangements provided which prevent the mill from doing its best work on the products which are most desired, so that the result is ultimately less satisfactory than could have been obtained had the purchaser listened to sound engineering advice.

While Mr. Sheperdson made this point only as a side issue to his general discussion, it struck me particularly on account of the similar experiences which I have had. In discussing it, I would not detract from the body of the paper which I have listened to with great interest, and which has been very instructive.

Mr. J. W. Sheperdson: I welcome the emphasis you have given to what I passed over rather lightly. The present age of intensive production and of using special equipment for special purposes has taught us many things in economy that can very properly be applied to the production of hot-rolled steel products. Where this application has been made, very gratifying results have been secured. I heartily agree with you that we as engineers should support standardized production in rolling-mills in the interests of our steel industry.

Mr. George A. Paff:* I would like to add one thing to what Mr. Sheperdson has said. The steel strike of 1919 demonstrated very forcibly the fact that the labor incidental to the operation of a continous mill is greatly simplified as compared with the requirements of a Belgian mill. For example, one large and well disciplined corporation which employs Garrett mills almost exclusively, was forced to recognize this fact throughout the strike. In other words, the skilled labor of a Belgian mill is usually so closely bonded together as to be almost the equivalent of organized labor, even though unions may not actually exist at such plants.

Mr. J. W. Sheperdson: Mr. Paff's position with regard to the labor problems on continuous and hand mills is well taken, but

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*Engineer, Wheeling Steel Corporation, Wheeling, W. Va.

I do not want the impression to be created that continuous mills do not require considerable skill in their operation. It is true that continuous mills do not require highly trained men to handle with tongs, day in and day out, bars running at speeds, which, while slow for continuous mechanical rolling, are about the limit of human speed, skill, and endurance. Continuous mills do, however, require a few expert men, whose familiarity with furnace and rolls will reduce the idle time of these mills to a minimum, and whose crews working in concert will clear a cobble and get the mill on again in the shortest possible time. The rolling-mill manufacturer can do only one thing—he can supply the mill and its auxiliaries; the mill can be made a success or a failure by the operating crew. Usually, continuous mills are a success from the start because the importance of having a good crew has never been minimized. In those few instances where equivalent results under equivalent conditions do not soon materialize, and there is ample precedent, the management is not slow to use such measures as will bring results up to par. The mills getting the best results are those having the best heaters, rollers, finishers, etc.

MR. GEORGE A. PAFF: I still maintain that, in the face of a strained labor situation, I will take my chances with the continuous mill as against a mill of the Belgian or Garrett type.

MR. J. W. SHEPERDSON: I fully subscribe to Mr. Paff's remarks regarding the relative ease of replacing the crews of Garrett and continuous rod mills. The latter really require a few first-class men who can whip almost any aggregation into a crew in short order.

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PROCEEDINGS

OF THE

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

EXPLOSION HAZARDS IN INDUSTRIAL PLANTS DUE TO THE USE OF PULVERIZED COAL - - - - - - - - *L. D. Tracy*

THE POSSIBILITY OF IMPROVED METHODS OF ROLLING SHEET STEEL - - - - - - - - *Sumner B. Ely*

PITTSBURGH
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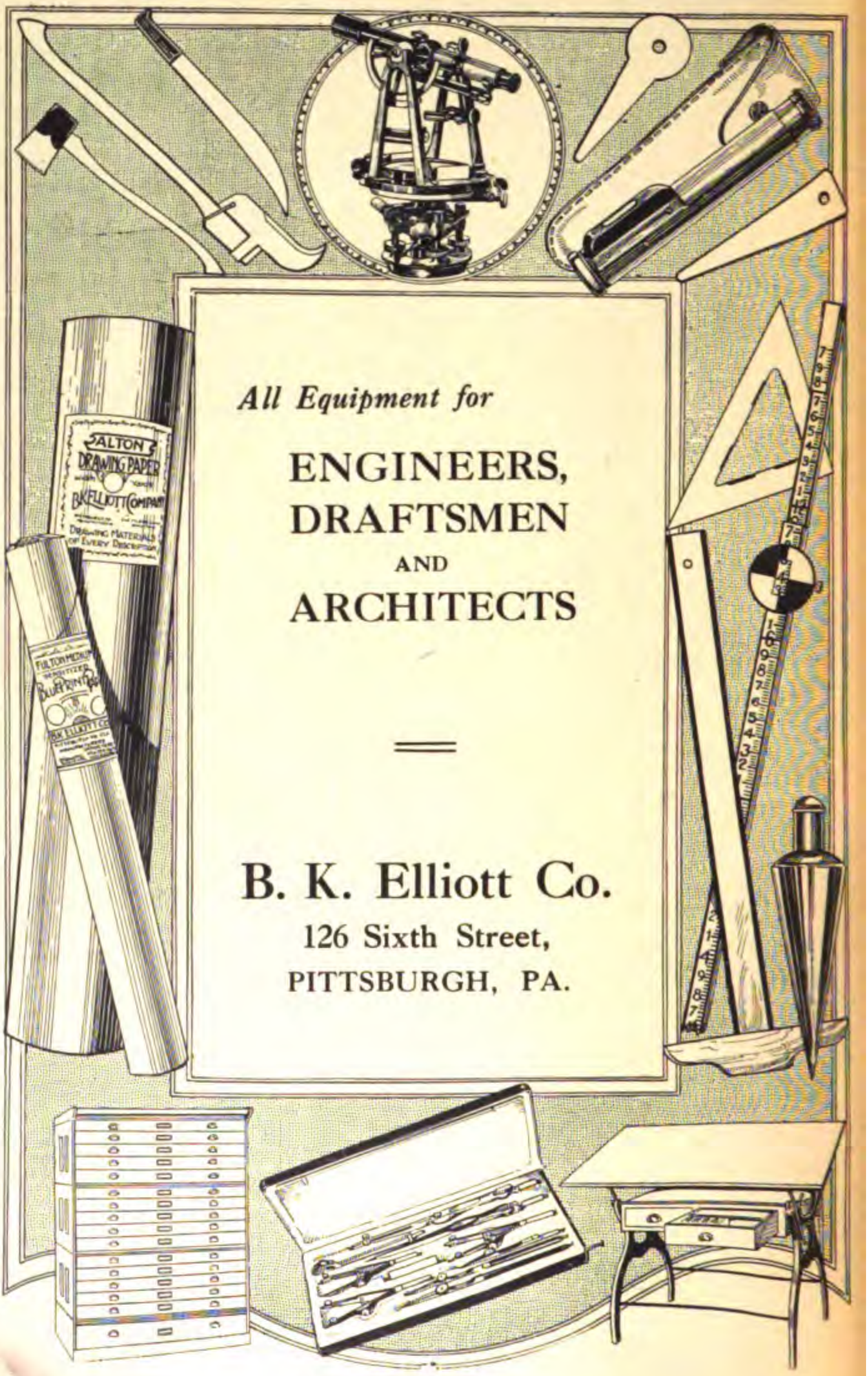

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EXPLOSION HAZARDS IN INDUSTRIAL PLANTS DUE TO THE USE OF PULVERIZED COAL*

By L. D. Tracy†

Since the introduction of pulverized coal as a substitute fuel for natural gas in the various types of heating furnaces used in the steel mills, a number of fires and explosions have occurred, resulting in the loss of life and property.

As one of the primary functions of the United States Bureau of Mines is to conduct investigations concerning the utilization of mineral substances with a view of increasing the safety in the use thereof, it was deemed advisable by the Bureau to investigate the hazards involved in the industrial use of pulverized coal, and, if possible, to devise methods of preventing future accidents therefrom. The knowledge of the explosive qualities of coal-dust which the Bureau has gained in studies affecting dust explosions in coal mines has been of material assistance in these investigations. Several plants were visited in which either fires or explosions had occurred and data obtained as to the probable cause of the accidents.

In order to make clearer the points which the writer desires to emphasize in this paper, it may be advantageous to give a brief description of the general arrangement of a coal pulverizing plant.

Before coal in a very finely divided state can be used for fuel, certain preparation is necessary. It must be crushed, dried, pulverized and then conveyed to the furnace or boiler where it is to be used.

Generally speaking, there are two distinct methods in use which, for the sake of convenience, I am going to term the direct and circulating methods of using pulverized coal. Both methods employ practically similar processes, varying perhaps in detail, in the preparation of the coal, but differing in the manner in which the pulverized coal is transported to the furnaces.

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†Coal Mining Engineer, U. S. Bureau of Mines.

In the circulating system (Fig. 1), after the coal has been pulverized, it is fed in regulated quantities to a fan, by which it is forced in a cloud through pipe lines, ranging from 8 or 10 inches to 14 or 16 inches in diameter. Branch lines leading from the main line to the furnaces, convey the coal as may be needed; the surplus coal, which has not been drawn from the main line, returning near the point of beginning where a separator removes the coal-dust from the air, returns it to a storage bin, again to be blown through the line. In other words, it is a continuous circulation of coal-dust, and is somewhat analogous to a gas line, where the fuel is drawn off as needed. Secondary air lines, independent of the main coal feed line, provide the additional air at the burners necessary for proper combustion.

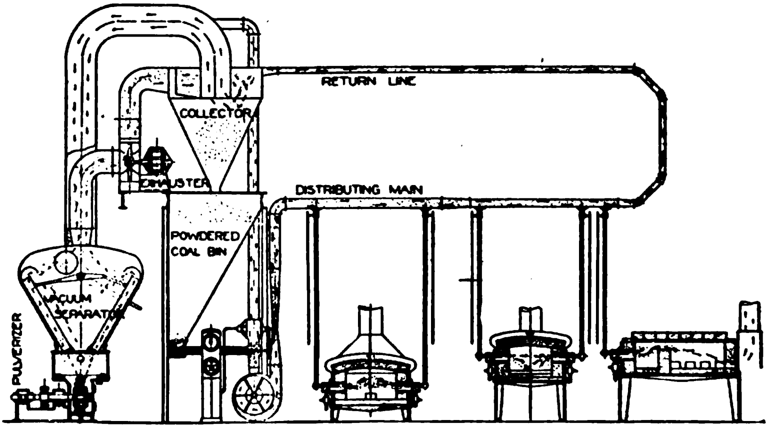


Fig. 1. Diagram of Circulating System of Pulverized Coal Distribution.

The indirect system (Fig. 2), transports the coal either by means of compressed air, under perhaps 90 pounds pressure, or by screw conveyors to bins at the furnaces. From these bins, the pulverized coal is fed, generally by screw conveyors, to an air blast which carries the fuel into the burner.

As a rule the building in which the crushing, drying, and pulverizing machinery is located is separated from the industrial portion of the plant, and the writer believes that this is desirable from a safety standpoint. Explosions and fires which have been known to occur in coal pulverizing plants might have been more disastrous if they had happened in buildings housing both the pulverizing machinery and the manufacturing department.

In connection with the pulverizing plant, the essential element for safety is absolute freedom from an accumulation of dust on open exposure.

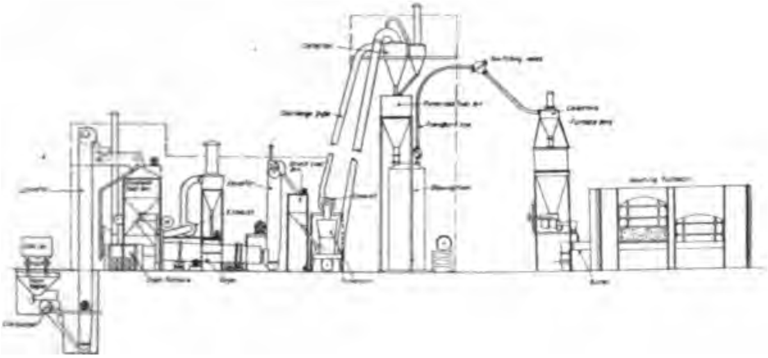


Fig. 2. General Arrangement of Indirect System of Pulverized Coal Distribution.

Fig. 3 illustrates very forcibly the disastrous effects due to an explosion of a dust cloud in a pulverizing plant. There is no doubt but that the accumulated dust in this building was raised in a cloud and ignited by a smaller explosion in some part of the machinery.

Adequate ventilation is absolutely necessary in a pulverizing plant. The writer was in a plant in which a recent explosion occurred and which was so dark and dusty that the electric lights did not illuminate the building sufficiently to allow one to find his way around readily. Fine coal-dust in the air was so thick that it seemed as if one might be looking at the electric light through a smoked glass. Accumulations of dust over one-fourth inch in thickness were found all over the machinery and floor. Yet they were not conspicuous because of the dark condition of the room. It is unwise, however, to depend entirely on ventilation to overcome the powdered coal-dust hazard, for the reason that there are many angles and corners in a building which the air currents never reach and where the suspended dust will settle. It takes only a very small quantity of coal-dust per cubic foot of air to cause an explosive mixture. In tests by the Bureau of Mines a mixture of 0.032 of an ounce of coal-dust per cubic foot of air has been sufficient to cause an explosion when brought in contact with a flame. The comparison may be shown by the amount of dust contained on a silver quarter of a dollar as compared to the size of a cubic foot of air. (See Fig. 4).

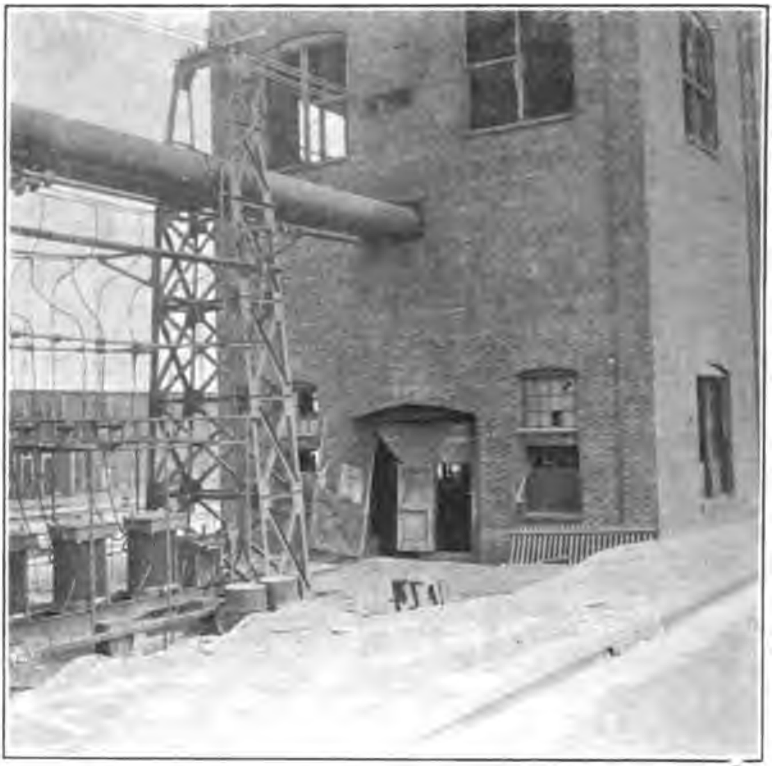
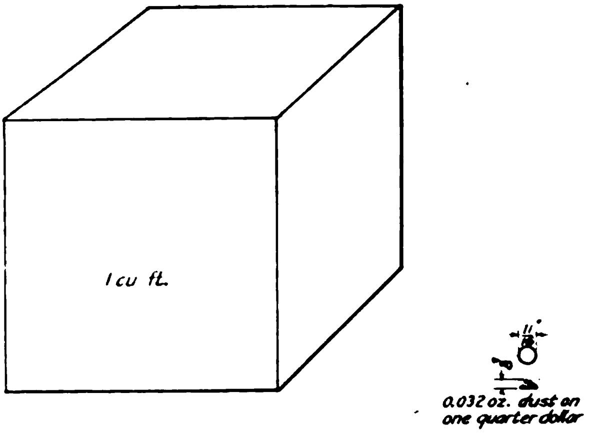


Fig. 3. Effect of a Coal-Dust Explosion in a Pulverizing Plant.

It is believed that it is practicable to install in a coal pulverizing plant a vacuum cleaner system by which all parts of the building in which dust is liable to settle may be reached.

This has been done in some of the coal crushing plants in France and Germany. Dust should never be brushed or swept up without being thoroughly wet down. This applies not only to the pulverizing plant but also to the industrial portion of the operation.



The amount of dust which a silver quarter of a dollar will hold is the minimum amount per cubic foot which will explode.

Fig. 4. Diagram Showing Amount of Dust per Cubic Foot of Air in an Explosive Mixture.

Some time ago the Bureau of Mines was requested to investigate conditions in a plant in which were installed a large number of small furnaces used to heat rods and bars from which nuts, bolts, rivets, and carriage hardware were manufactured. These furnaces were burning pulverized coal and it was found that a very fine dust had settled on the girders, pipe-lines, and runways and on the furnaces themselves. In some places accumulations of this dust were from one-half to three-fourths of an inch in depth. A large number of samples of the dust were taken and chemical analyses of these samples were made. Table I shows the result of some of these analyses as compared with pure coal taken from the same plant. See Fig. 5.

It will be seen that the percentage of volatile matter and fixed carbon in some of these samples does not differ greatly from that in the pure coal-dust.

TABLE I. COMPARATIVE ANALYSES OF MILL DUST AND PURE COAL-DUST

Laboratory number	Material	Volatile matter	Fixed carbon	Ash	Ratio of volatile matter to total combustible $\frac{V}{FC+V}$	Remarks
31398	Pure coal	36.81	52.84	9.28	0.42	Explosive
31373	Mill dust	23.54	51.24	24.36	0.31	Explosive
31372	Mill dust	20.61	50.88	27.43	0.28	Explosive
31376	Mill dust	15.91	53.26	29.76	0.23	Slightly explosive
31375	Mill dust	10.99	56.29	31.83	0.16	Slightly explosive
31378	Mill dust	7.17	63.68	27.78	0.10	Non-explosive

For a number of years the Bureau of Mines has investigated at its experimental mine, the explosive properties of coal-dust, especially with reference to the amount of incombustible matter which it is necessary to mix with pure dust from Pittsburgh coal to render the coal-dust non-explosive.

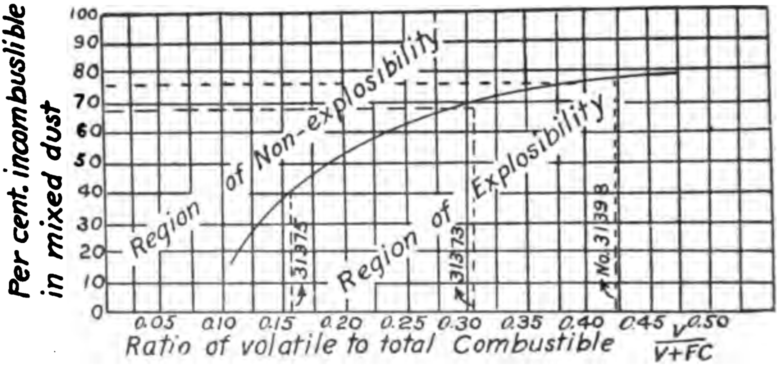


Fig. 5. Curve Showing Border Line of Explosibility and Non-Explosibility in Coal and Inert Dust Mixtures.

The curve in Fig. 5 represents the border line between the region of explosibility and non-explosibility; the horizontal co-ordinates, the ratio of volatile matter to total combustible matter; and the vertical co-ordinates the percentage of incombustible matter in the mixed dust.

In the sample of pure dust from Pittsburgh coal in the table, the ratio of volatile to total combustion is 0.42. From the curve the amount of incombustible matter required to render this dust non-explosive is found to be about 75 per cent.

The sample of mill dust No. 31373 contains a ratio of 0.31, which would require about 68 per cent. incombustible matter. The amount of ash in this sample is 24.36 per cent., so that about 44 per cent. more would have to be added to prevent this dust from exploding if raised into a cloud and ignited.

The next to the last sample has a ratio of 0.16 and this would need about 38 per cent. in combustible matter to render it non-explosive. The ash content is 31.8 per cent. so that only about 7 per cent. more of inert matter is required in addition to the ash already present. The result of this analysis shows that the original dust is very near the non-explosive limit. The last sample is, in itself, non-explosive.

The foregoing illustrations are given for the purpose of showing the danger of an accumulation of partially consumed coal-dust. It also revealed to the operating company the inefficient combustion of coal taking place in the furnace. This was later remedied by some slight changes in the construction of the furnace.

It may be assumed by some furnace men that enough dirt may become mixed with the coal-dust on the floor around the furnaces to counteract the dangerous characteristics of the coal.

In Table II are the analyses of samples of dust which were brushed up from the floor around pair and sheet furnaces in two different operations. By comparing the ratios of volatile to total combustible matter it is found that in the

TABLE II. ANALYSES OF DUST FROM FLOOR AROUND PAIR AND SHEET FURNACES

Laboratory number	Material	Volatile matter	Fixed carbon	Ash	Ratio of volatile matter to total combustible $\frac{V}{FC+V}$
76725	Floor dust	25.66	33.07	40.48	0.43
34284	Floor dust	33.98	36.59	28.25	0.48

first instance it will take about 38 per cent. and in the second about 50 per cent. more incombustible matter than the dust already contains to render it inert.

The question might arise as to what the danger might be from this dust, inasmuch as the average building containing furnaces and rolls has very little to burn, and there are always flames and red-hot metal all around. The danger lies in the fact that if this dust is allowed to accumulate and should be raised in a cloud—either by a current of air coming in through an open window or door, or by any other means—and this cloud of dust should come in contact with red-hot metal about which men might be working, the chances are that the cloud of dust would be ignited and the men, perhaps, be fatally burned.

There are on record in the Bureau two actual instances in which accumulated dust has been the direct means of accidents, although, fortunately, no one was seriously injured. One of these was caused by a short-circuit in a starting switch in one of the motors in a steel-mill. Coal dust had gradually accumulated between the poles, and, absorbing moisture, it became a good conductor, thereby causing the current to short-circuit and burn out one of the switchboard panels in the power-house. The second instance was that of an accumulation of dust which was accidentally blown by air from a compressed air tank towards a furnace. The cloud ignited and the room was immediately filled with a sheet of flame.

It would seem desirable, from a safety standpoint, if the management of all industrial plants in which pulverized coal is used for fuel, and especially in those plants in which heating and annealing furnaces are installed, would impress upon their employees the fact that clouds of fine coal-dust are as dangerous as a body of unconfined natural gas, if the dust is liberated in close proximity to an open flame or mass of hot metal.

The writer investigated an explosion in a steel plant, undoubtedly due to coal-dust, and, in spite of the fact that one man was killed and two badly burned, the superintendent of that mill profanely insisted that coal-dust would not explode.

Two fatal accidents, identical in character, which the writer has personally investigated, were caused either through ignorance or the carelessness of the unfortunate victims. In each case the furnace was supplied with pulverized fuel from bins located almost directly over the furnace as shown in Fig. 6. These bins were evidently just being filled with pulverized coal from the central pulverizing station, and the pulverized coal was forced through a transport line by compressed air at a pressure of 80 or 90 pounds per square inch. The bins were tightly closed with a steel cover, a door being left in the cover for inspection purposes. Strict orders had been issued to keep this door closed. While pulverized coal was being delivered to this bin, the furnace man climbed to the top of the bin and opened the inspection door. Immediately the dust which had been more or less stirred up in the bin, came out of the door in a cloud, some of it dropping down by the furnace where it was ignited. Instantly it flashed up, enveloping the man in flames and burning him to death. The location of the bins over the furnaces is well shown in the illustration. Other accidents, although not involving loss of

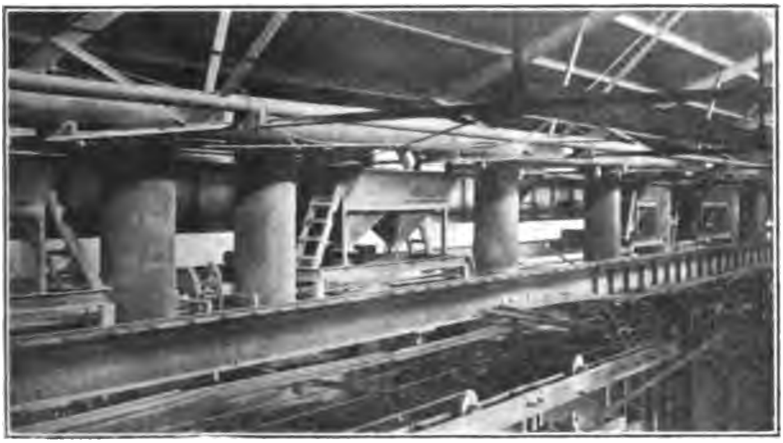


Fig. 6. View of Bins for Pulverized Coal Directly over Furnaces.

life, have been brought to the attention of the Bureau, and the causes have been almost identical with those of the fatal accidents just described.

Where furnaces or boilers are equipped with individual fuel bins and the pulverized coal is fed into the furnaces by means of an air blast, it is the belief of the writer that the bins should be placed away from the furnaces, or, at least, a barrier built to prevent possible dust clouds from coming in contact with the fire or hot metal at the furnaces.

Fig. 7 shows the installation of fuel bins on the outside of the building. The coal is fed into the air line by screw feeds and the lines are carried under the floor to the furnace. The fan and secondary air line can be seen under the bin.

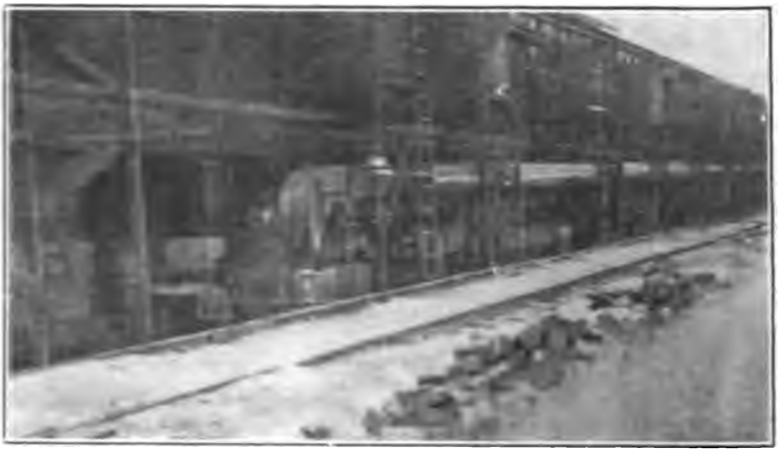


Fig. 7. View of Pulverized Coal Bin Installation on Outside of Main Building.

Fig. 8 shows a somewhat different type of installation, part of the bin being above the roof of a small shed-like structure, and it also plainly snows the main coal-transport line. Fig. 9 shows the bottom of the bin and the feed lines to the furnace. In this installation the lines are above the floor, a corrugated iron partition separating the bottom of the bin from the furnace.

The question which immediately presents itself in reference to the placing of the bins in the open air, is whether or not the cold weather would cause trouble by moistening the coal and thus prevent its free transmission to the furnace. These bins were constructed last fall and I am advised by the management that during the winter no trouble at all has developed. The advantage gained is the high improbability of a dust cloud coming in contact with the furnace, either through carelessness of the workman or in any other manner, and it is believed that this type of installation is worthy of serious consideration by operators using this system of burning pulverized coal.

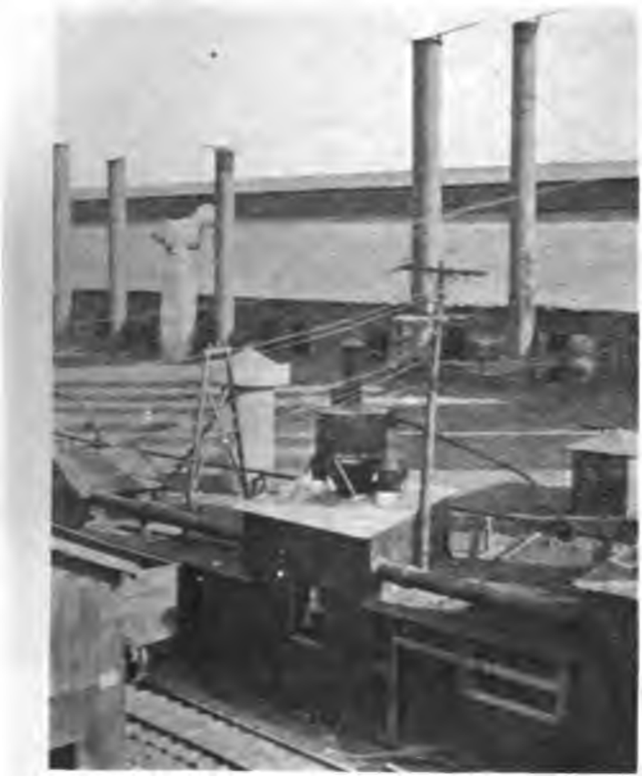


Fig. 8. Storage Bin Outside Building.

One of the most serious troubles with which the users of pulverized coal have had to contend, has been the number of fires which have occurred in the dried coal and the storage bins. It has been somewhat difficult to determine the exact cause of these fires, but there can be no doubt but that spontaneous combustion has played an important part in some of them.

Unfortunately, as far as the writer can learn, no work has been done to determine the rate of oxidation of coal under the conditions which govern its use in pulverized coal systems. However, quite extensive investigations have been carried on relative to the spontaneous combustion of coal under somewhat different circumstances, and some of the results of these investigations can be utilized in the study of fires in bins for pulverized and dried coal.

It is perfectly obvious that coal in a fine state of division presents a much larger surface and brings a much larger quantity of reacting substances in contact with oxygen than when in solid masses.

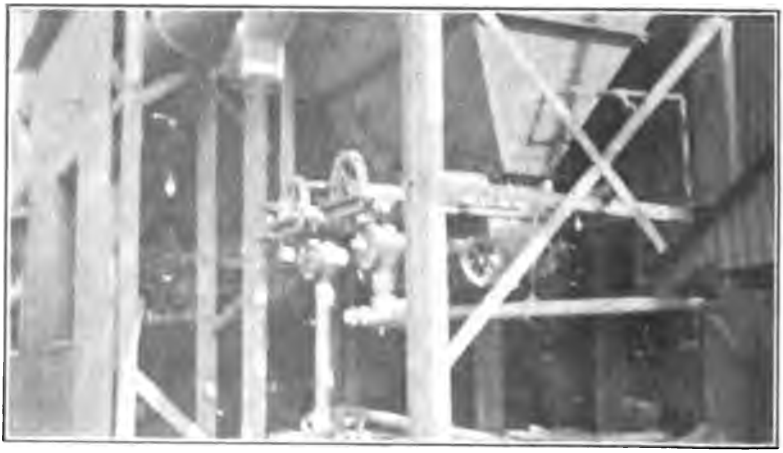


Fig. 9. Bottom of Storage Bin.

In tests by Parr and Kressman, described in an article on the "Spontaneous Combustion of Coal" published in the University of Illinois Bulletin 46, (1910), it was learned that "The rate of absorption of oxygen increases so greatly with the rise of temperature that the warming of coal by a steam-pipe or boiler may enormously shorten the time necessary for spontaneous combustion or render spontaneous combustion possible in cases where it would otherwise be impossible."

In experiments carried on by the United States Bureau of Mines and described in Technical Paper 65 by Horace C. Porter and A. C. Ralston, entitled "A Study of the Oxidation of Coal," it has been determined that the rate of oxidation of coal increases rapidly as the temperature increases.

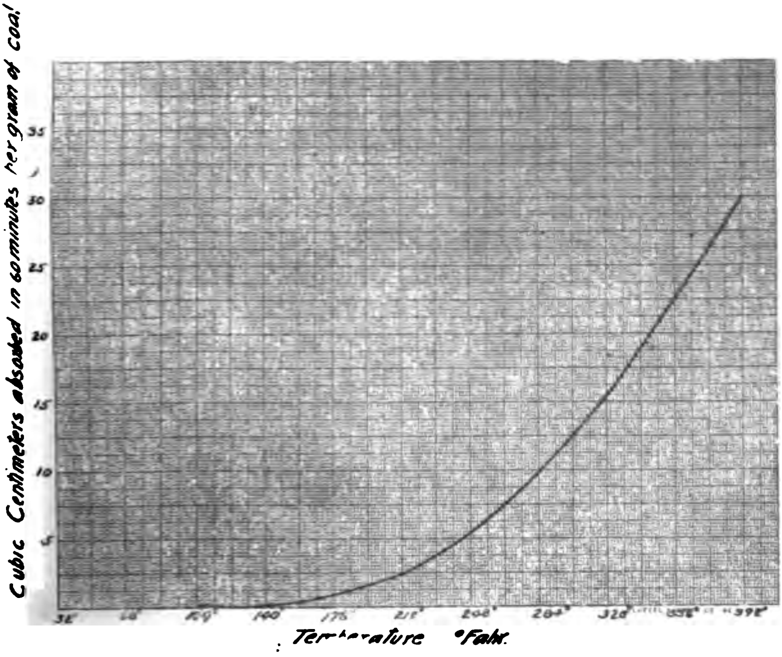


Fig. 10. Curve Showing Rate of Oxidation of Illinois Coal at Different Temperatures.

Fig. 10 shows the rate of oxidation of Illinois coal (80 to 100 mesh in fineness) at different temperatures. It will be noted that above a temperature of 150 degrees F., the rate of oxidation is very rapid. This confirms experiments in England carried on by Richard Threlfall.*

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*Journal of the Society of Chemical Industry, 1909, v. 28, p. 759.

As the amount of heat generated is in direct proportion to the amount of oxygen absorbed, it is reasonable to assume, from the above-mentioned results that pulverized coal, when delivered to storage bins at a fairly high temperature, will in a short time approach the ignition point.

As far as the writer has been able to ascertain, the companies who manufacture and install coal-pulverizing systems advocate a drying temperature of from 100 to 150 degrees F., at which temperature the coal is delivered to the storage bins. Unfortunately, however, the human element plays an important part in the operation of the drier. For instance, one cold night not long ago the man operating the drier evidently built up an exceedingly hot fire in the drier furnace because at the time the consequent explosion occurred the pyrometer in the stack end of the drier registered 320 degrees F. and, as the dried coal was delivered at the furnace end of the drier, it is probable that the temperature of the coal was considerably higher.

At another plant at which a fatal explosion occurred, and which was investigated by the writer, it was learned that the pulverized coal was delivered to the bins at a temperature of 230 degrees F. Some of the workmen in the mill stated that at times the sides of the steel bin became red hot.

At this point I want to digress a moment to speak of the effect of high drying temperatures as a matter of efficiency. The writer has heard complaints that with coal dried at high temperatures there was still moisture in the bins. Paradoxical as it may seem, coal dried at abnormally high temperatures will cause more moisture than when dried at a temperature from 100 to 150 degrees F. The reason for this, as given by the Fuel Section of the Bureau of Mines, is that very hot coal carries with it, as it travels from the drier, a certain amount of vapor, due to the evaporation of moisture in the surrounding air with which the hot coal is brought in contact. This accompanies the coal to the bins and is condensed by the colder sides of the bins and conveyors. It is possible that better results would be obtained if the coal were dried at a stack temperature of from 100 to 150 degrees F. This might give a coal surrounded by a drier atmosphere and obviate the condensation on the sides of the bins.

Returning to the subject of abnormally hot coal in the bins, it is reasonable to assume from the data given on spontaneous combustion that any coal which is delivered to the storage bins at a temperature of 150 degrees F., or above, if left in the bin for a comparatively short time will attain such a temperature that when mixed with air it will quickly reach the ignition point.

Besides the building of an abnormally hot fire, there is one other way in which coal may be overheated in a drier and that is by allowing coal to remain in the drier drum when the drier itself is not running although only a normal fire is maintained in the drier furnace.

It is believed that fires in storage bins for pulverized coal, oftentimes due, no doubt, to spontaneous combustion, have been responsible for some of the fires in those coal-circulating lines in which the pulverized coal is blown in a dense cloud to the furnaces.

The Bureau of Mines has investigated a number of cases in which, almost without warning, flames have burst from the coal circulating lines. As far as could be ascertained, the lines were free from any obstruction; the fans were operating normally and the burners at the furnaces had been giving no trouble. It seems perfectly logical, therefore, to assume that the pulverized coal in the bins had been heated by spontaneous combustion to almost the ignition point, and when conveyed to the coal circulating line, enough additional oxygen was supplied by the air current induced by the fan to produce incandescence in the particles of coal which, in turn, ignited the dust cloud passing through the line.

A peculiar phase has presented itself in the investigation of these fires, in that under apparently the same conditions, at one time considerable violence will be noted while at another time there will simply be a heating of the line to a red heat with flames coming out at the joints, and no explosion. The reasons for the different behavior of the hot dust under these apparently similar conditions are not definitely known. It is thought, however, that it is because of the variation in the mixture of coal-dust and air. In fact, some of the explosions have taken place just beyond the last feed line to a furnace where there evidently was a much leaner mixture of air and dust than at the point where the line was simply burned out. The point to be emphasized, however, is that extreme care should be taken to prevent overheated coal from being carried to the storage bins. The entire safety of the pulverizing plant largely depends on the man tending the fire in the drier. If he is careless and allows an abnormally hot fire in the grate-bars of the drier, the chances for overheating the coal are very great; or, if he should stop the operation of the drier and at the same time maintain a hot fire, hot coal will result. The Bureau has on record instances of hot coal being carried direct to the pulverizers with the result that the dust in the pulverizers was ignited and exploded with such violence that the pulverizing mills were badly wrecked.

A drier should never be stopped with coal in the drum unless the fire on the grate-bars is pulled; and a fire should never be started in a drier furnace with shavings, paper, or any light combustible material that may be carried by the draft into the interior of the drier.

A pyrometer with a recording chart placed in the superintendent's office would be an effectual check on the operation of the drier. The thermo-couple should be placed at the most accessible point nearest the discharge end of the drier, so that it will give the temperature of the dried coal.

To guard further against spontaneous combustion, storage bins for pulverized coal should not be placed in any position where they may become heated from furnaces, steam-pipes or hot flues.

Whenever a plant has been shut down for a few days, before allowing pulverized coal to be delivered through transport lines to the place of consumption, an examination should be made to ascertain whether or not it has become heated to such a point that it will ignite when brought in contact with a current of air. This can be done by pushing iron rods into the interior of the stored coal and leaving them for a short time. When they are withdrawn, the temperature of the rod will indicate whether or not there is any fire in the bin.

Some of the fires which have occurred in those plants in which the circulating system of pulverized coal is used, have undoubtedly originated from back-fires from the heating furnaces. These back-fires have been probably caused by the air-pressure in the distribution line suddenly dropping below the secondary air-pressure. By secondary air-pressure is meant the additional air-pressure, provided by blowers or otherwise, which furnishes sufficient oxygen for the proper combustion of the coal in the furnaces. The average pressure used in this system is about nine ounces in the main distribution line and about four ounces in the secondary line. The air for the distribution line is generally furnished by a blower fan which is operated independently of the one on the secondary air line. The drop in pressure in the main distribution line may be due to the sudden stopping of the fan which supplies the air current for transporting the coal or to an obstruction in the air line; or, possibly, the coal line may be overloaded—by that, I mean the placing of so many furnaces on the line that the last one or two furnaces receiving fuel may reduce the air-pressure to below that of the secondary air. When this happens there is a tendency for the secondary air to "short-circuit" and travel up the coal-feed line into the main circulating line, carrying with it the hot gases and incandescent particles from the burner, and thus igniting the fine coal in the circulating line. It may happen, if the primary air in the circulating line is temporarily shut off, that there will not be enough oxygen in the line to support combustion, and the mass will simply smolder until the current again becomes normal when the smoldering coal will be fanned into flames. Wherever booster fans are used in the distribution system, it is extremely important that the pressure on the intake side of the booster fan be kept positive—otherwise, air will be drawn from the furnaces with the same result as a back-fire.

There is one other source of more or less trouble, and that is the coking on the burners. The general experience seems to be that the burner becomes hot at the extreme end, due to several reasons, such as too much coal for the amount of air, or slowing down of the secondary air blower from power fluctuations. The coal then begins to stick on the burner, and, as the accumulation increases, the area of the burner is decreased and sometimes the burner actually becomes plugged; and, as the secondary air has no other outlet, the current will tend to deflect into the coal supply line, taking red-hot dust with it and eventually causing a fire or explosion in the main circulating line. To avoid this, frequent inspection of the burners should be made, and, if the least tendency to coke is shown, they should be immediately cleaned. Some of the steel-mills employ a man whose sole duty is to inspect and clean burners.

There is a practice in some of the mills, when shutting down at the end of the day's work, of leaving a small amount of coal lying in the bottom of the coal-transport line. The reason given is that the furnaces can be started much more quickly than when the line has been blown clean the night before. This is rather a dangerous practice, as the mixture of dust and air is, of necessity, a lean mixture, perhaps at its most explosive combination; and if, through any chance, hot coal has gotten into the line, an explosion is bound to occur. In the interest of safety, when the plant closes down at night, all furnaces should be cut off from the supply line, the main pulverized coal bin cut off from the main circulating line, and the line thoroughly cleaned by allowing the fan to force a current of air through it until all the pulverized coal is blown out.

Instances have been known where the explosion wave traveled the length of the coal-circulating line, finally terminating in the fan, wrecking the fan casing and the fan. At the experimental mine of the Bureau of Mines, where a large number of coal-dust explosions are studied, the ventilating fan is placed in an entry which makes an angle with the main air course, and explosion or release doors are installed. This allows the explosion wave to travel straight down the entry without injuring the fan.

Fig. 11 shows an ineffective and an effective way of connecting up a fan so that explosions in the coal line will cause the least damage. The sketch in the upper part of the figure illustrates the ineffective method—ineffective, because the explosion wave will not accommodatingly turn the acute angle and go out the relief valve, but will continue straight to the fan. In the lower sketch the relief valves are placed at the end of the straight line. Scheme No. 1 is shown in plan and scheme No. 2 in elevation.

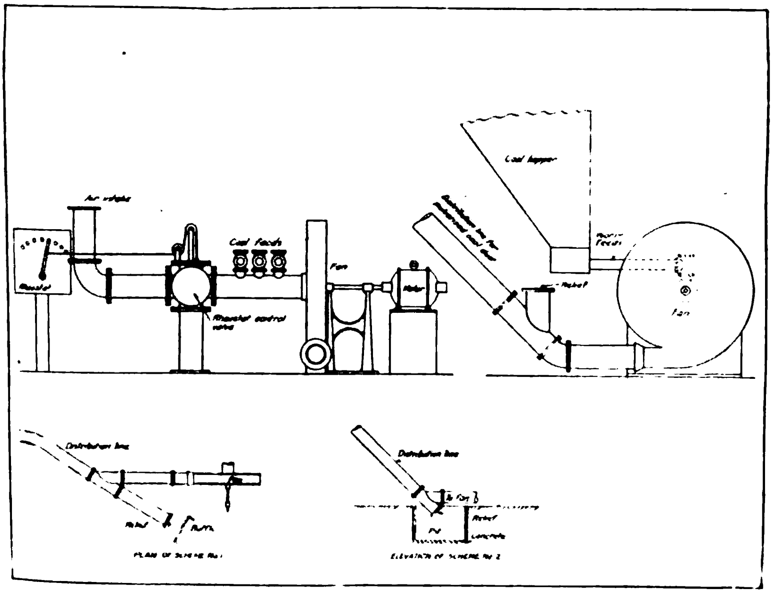

Fig. 11. Diagram of an Effective and an Ineffective Method of Connecting Distributing Fan to Minimize Damage by Explosions.

In all coal-pulverizing plants, electricity plays a large part and it is extremely important that the electrical equipment be of such a type and installed in such a manner that the danger of ignition of the pulverized coal by an electric arc shall be reduced to a minimum.

All electric wires and cables should, as far as possible, be carried in conduits. At one plant visited by the writer, the bin for pulverized coal also acted as a support to wires carrying several hundred volts of electricity.

The switches at the pulverizing plant should, if possible, be placed outside the building housing the pulverizing equipment; or, at least, as far as possible, should be of the oil-immersed type. The incident related in the first part of this paper of the switch which was short-circuited by dust is one illustration of the danger of the open-type switches around coal-pulverizing plants. Motors of the non-sparking type, preferably squirrel-cage motors, are the nearest to explosion-proof motors now available. Even with this type of motor, some of the steel-mills have had trouble with dust accumulating in the windings, and eventually causing a short-circuit, notwithstanding the practice of frequently blowing out the motors with compressed air. The tendency of the air pressure is to pack the dust more firmly in the windings.

Perhaps one of the best illustrations of the danger of coal-dust settling on the inside of electric-motors is the explosion which occurred in the pulverizing plant at the New Brancepeth Colliery, England. The pulverizer was operated by a 25-horse-power, 500-volt, direct-current motor. The motor was enclosed, but not explosion proof, and stood on a platform about six feet above the floor. A short-circuit of one of the armature coils caused much sparking, thereby igniting the coal-dust inside the motor casing, and caused an explosion of sufficient force to blow off the sheet-iron cover over the commutator end of the motor. The flame thus produced was sufficient to explode the fine dust held in suspension within the building. The flames extended six feet outside the open door and to a height of 15 feet inside.

In its work along the lines of lessening the number of fatalities in coal-mines, the Bureau of Mines has developed a schedule of requirements for the construction of electric-motors in coal-mining equipment, which enables safe operation in gaseous and dusty mines. When such motors have passed this schedule, and have satisfied the tests involved, they are classed as "permissible motors." It seems to the writer that it would be perfectly practicable to build similar "permissible motors" for use in all plants in which dust may be an explosion hazard, and this suggestion is offered to those who may be identified with the manufacture of electrical equipment.

All machinery should be thoroughly grounded, in order to prevent sparks due to static electricity.

It is not known with absolute certainty whether or not the glowing filament from a broken incandescent electric-light bulb will ignite a cloud of pulverized coal; however, considerable investigation has been made of the effect of different lamps on the ignition of grain dust and it seems to the writer that the results might be applicable to coal-dust. In any event, if it is found that the results are not the same for coal-dust as for grain dust, the error in applying them would be on the side of safety. This subject is dealt with in quite a thorough manner by C. L. Dows and E. B. Fox of the General Electric Company and W. P. Blackwell of the Westinghouse Lamp Company in an article entitled "Lighting for Dusty Places."* It is to this article that the writer is indebted for some of the following information.

Fires in connection with electric lamps may be due to two causes—the ignition of dust collecting on lamp bulbs, and the accidental breakage of incandescent lamps in an atmosphere containing the proper proportions of dust and air to render it explosive.

It has been found that all vacuum lamps up to and including 100 watts, and some of the lower wattage gas-filled lamps, may be safely used where dust has a high ignition temperature. There is danger of fire, however, if these lamps become thickly coated with dust. It must always be remembered that any lamp will start a fire if operated continuously in conditions which allow the accumulation of heat. For instance, if a lighted portable lamp should be carelessly left hanging in an empty, pulverized-coal bin, and the bin should be suddenly filled with coal, completely burying the lamp, the coal would eventually ignite. The second possible cause of ignition—that of broken bulbs—is the more important. Fine grain dust having a high carbon content, when combined with air in the right proportions, has been ignited when an incandescent lamp has been broken in such dust clouds; and it is reasonable to assume that, under the same conditions, a cloud of finely pulverized coal would act in a similar manner, although no specific case can be cited.

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*Electrical World, 1921, v. 77, p. 191.

When portable electric incandescent lamps are used to illuminate any place in which there is liability of a pulverized coal-dust cloud forming, the bulb should be protected with a wire guard. The insulation of the wire carrying the current should be carefully examined to see that there is no unprotected wire by which a spark could be caused by coming in contact with metal, and the sockets and other connections should be in such condition that a short-circuit would be impossible.

One of the most important of all safety measures is the education of the men in the pulverizing plant, and especially those who are in and around furnaces or boilers which are using pulverized coal, to the idea that coal-dust is explosive and inflammable when in a cloud and mixed with air, and that it should be treated just as carefully as natural gas. A little stream of pulverized coal leaking from a defective joint in a coal-transport liner or a storage bin perhaps will not attract much attention, while a leak from a gas line would be immediately repaired; yet this same cloud of coal-dust may be potentially as dangerous as unconfined gas.

To those who are interested in the use of pulverized coal as a fuel, the writer would offer the following summary of this paper as a basis for regulations looking to the safer operation of pulverized fuel plants:

There should be absolute cleanliness, and freedom from any accumulations of dust, both in the pulverizing plant and in the buildings in which the pulverized coal is being used as fuel.

Accumulations of dust on the floor or machinery should never be brushed or swept up without either wetting the dust or thoroughly mixing with an excess mixture of fine incombustible material.

All coal pulverizing plants should be adequately ventilated and lighted and, when practicable, some method of cleaning by vacuum systems should be installed.

All open lights in and around coal pulverizing plants should be prohibited, and employees should not be allowed to smoke while in the building. This rule should apply to superintendents and other officials who casually visit the plant, as well as to the regular attendants.

The drier and drier furnace should be separated by a fireproof partition from the pulverizing mills, conveying machinery, and storage bins.

Where furnaces or boilers are equipped with individual fuel bins, these bins, if possible, should be isolated from the boilers or furnaces.

All pulverized coal bins should be tightly closed and never opened if there is any possibility of ignition from an open flame. Bins should be equipped with automatic indicators to indicate the amount of coal in the bin.

Only men of known reliability should be intrusted with the direct operation of a drier. It may be more economical in the long run to pay a higher wage to a good man than a smaller wage to an unreliable man or boy.

Especial care should be taken in order not to overheat the coal in the drier, and recording pyrometers should be installed to enable the officials of the plant to check the operation of the drier.

The operation of the drier should never be stopped while it contains a charge of coal.

Fire in the drier furnace should never be started with paper, shavings, or any light combustible material.

Because of the liability of spontaneous combustion, fine coal at a temperature over 150 degrees F. should never be stored in a bin. For the same reason, storage bins for pulverized coal should never be placed in close proximity to furnaces, boilers, steam pipes, or flues.

Whenever a plant is to be shut down for a few days, all storage bins should, if possible, be emptied of coal. Where it is not possible to empty the bins, they should be thoroughly inspected for hot coal, before the plant is again put in operation.

In the circulating system of using pulverized coal the primary air-pressure should always be maintained at a much higher pressure than that of the secondary air.

If a coal-circulating line becomes plugged up, the furnaces should be immediately cut out and the secondary air stopped.

After the line has been cleaned, it is essential that no smoldering particles of coal be left in the line, and before starting the fan a thorough examination of the line should be made.

Burners should be frequently inspected, and any coke burned thereon should be removed.

Circulating lines should be blown clean of coal when shutting down at the end of the day's work.

The mixture of air and coal in the furnace should never be ignited by reaching in, or opening the doors.

All conveyors and elevators should be tightly inclosed and should never be opened while running. Before opening, the machinery should be stopped and the dust allowed to settle.

A coal line, compressed-air tank, or storage bin should never be opened in the vicinity of a flame or open light.

All electric wires and cables should, as far as possible, be inclosed in conduits.

All switches should be placed outside the pulverizing plant, or placed in dust-proof casings.

Non-sparking motors or motors in dust-proof housings should be used in the pulverizing plant.

Precaution should be taken against sparks from static electricity in all rapidly moving machinery by having it thoroughly guarded.

All electric-light bulbs should be kept from accumulations of dust, and all portable lights should have the bulbs protected by heavy wire guards and care should be taken to prevent arcing from loose socket connections or imperfectly insulated cords.

All leaks in pulverized coal circulating lines or storage bins should be stopped as quickly as a leak in a gas line.

All the men should be educated to the dangers of pulverized coal-dust.

The use of pulverized coal as a substitute for natural gas for fuel in industrial plants, especially in those plants using different types of heating furnaces in the manufacture of steel products, will, no doubt, increase as the supply of gas decreases. This increase will probably develop safer and more efficient methods in the preparation and distribution of powdered fuel.

In order to further its work in the conservation of life and property, the United States Bureau of Mines will appreciate the co-operation of those connected with the installation and operation of pulverized coal plants by bringing to its attention suggestions which make for better efficiency and greater safety.

In presenting this paper, the writer desires to emphasize the fact that he has not intended to criticize any particular system of using pulverized coal nor to discuss their relative merits; but rather to present the facts as he believes them to exist, with the idea in mind of being mutually helpful to those installing the different systems and to those using them.

DISCUSSION

MR. HARVEY ALLEN :* The paper covers the question in a very complete manner, leaving very little more to be said. It is generally understood that the explosive range of pulverized coal and air mixtures is very much less than it is for natural gas and air mixtures. Some engineers claim that a mixture of anything below 100 cubic feet of air to a pound of coal is non-explosive and over 250 cubic feet of air to a pound of coal is non-explosive. A mixture of 0.032 of an ounce of coal to one cubic foot of air, as given in the paper as an explosive mixture would be 500 cubic feet of air to one pound of coal. Perhaps Mr. Tracy could give us some figures covering the exact ratios for explosive mixtures, if such have been determined at the Bureau of Mines.

Generally, it would seem that danger from explosions with pulverized coal is not nearly so great as it is with natural gas. It is a common occurrence for blast lines in forge plants where natural gas is used, to be partially or wholly wrecked by explosions. This is a source of considerable business for several firms of tinners in the Pittsburgh district. Pulverized coal explosions are likely to be more destructive of property, as much more machinery and equipment are required for preparing and handling this fuel.

As a matter of general information it would be of interest to know the relative size of a coal-dust cloud as compared to the confined space that would cause an explosion, instead of being merely a flash such as would result from a coal-dust cloud burning in the open air, unconfined. Perhaps the Bureau of Mines has published this information, but I do not remember seeing it. It is a question of expansion, and perhaps Mr. Tracy could give us some interesting ideas on this which might also help in determining sizes for combustion chambers of furnaces.

The paper mentions a vacuum cleaner system for use in a coal pulverizing house. One of the largest vacuum cleaners as made by the American Radiator Company with complete suction system has been in use for some time in the large pulverizer house at the McKees Rocks plant of the Pressed Steel Car Company. This makes a good practical apparatus to clean up dust, returning it to the pulverizer through the feed line, and avoids wetting down the dust as would be required for sweeping.

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*Efficiency Engineer, Pressed Steel Car Co., Pittsburgh.

Coal-dust lying around on floors, on beams, and in corners, has undoubtedly been the cause of many pulverized coal explosions, and it is evident that ordinary cleanliness about the pulverizer house and furnaces must be maintained simply as a matter of safety; this and the matter of designing so as to avoid explosions are well covered in the paper.

As to fires in pulverized coal storage bins—after an organization has contended with one or two such fires, means will be found to avoid them in the future, as handling such fires is a difficult and disagreeable piece of work. The paper is very comprehensive in the matter of operating coal driers with safety; also in regard to installation of electric equipment.

Pulverized coal has caused explosions in some plants because false notions as to its danger allowed a careless and dirty way of operation to exist which finally resulted in disaster. Other explosions have been caused by defective design of transport lines, improper placing of bins, etc. The paper of the evening covers these well, giving very valuable and timely information on a subject which will no doubt become more interesting to engineers of this district in the near future.

MR. L. D. TRACY: In regard to the explosive range of a mixture of pulverized coal and air: I believe the figure which I gave of 0.032 of an ounce of coal per cubic foot of air is about the minimum mixture which the Bureau has been able to explode with any degree of regularity. As to the maximum amount of coal-dust which will explode in a cubic foot of air, I do not think that the Bureau can give any definite figures. There are several difficulties which enter into the exact determination of this amount. For instance, in a mine, after an explosion has been started, an excess of dust does not have a blanketing effect, although it does have such an effect when applied at the point of origin. Another difficulty is in getting a dense homogeneous cloud. You might have a given number of ounces of dust in a given space, and this dust raised into a cloud. A flame applied at the center might be extinguished, but, when brought in contact with the cloud near the outer edge, would immediately ignite it.

I believe the safe thing to do is to consider all coal-dust clouds dangerous when brought in close proximity to an open flame.

I regret very much that I cannot furnish Mr. Allen any figures showing the relative size of coal-dust cloud as compared to the space that would cause an explosion rather than just a flash. As far as I know, the Bureau has never done any work along this line. However, some interesting data on pulverized coal combustion have been obtained in tests made by the Bureau on a boiler of the Oneida Street station of the Milwaukee Electric Railway and Light Company. This data is contained in a paper by Mr. Henry Kreisinger and Mr. John Blizard which is to be read at the meeting of the American Society of Mechanical Engineers in Chicago on May 23, 1921.* I believe that they obtained the best results when the coal was burned at the rate of 1 to 1.5 pounds of coal per cubic foot of combustion space per hour.

MR. WALTER GREENWOOD:† In discussing the paper by Mr. Tracy we must admit there is not much room for controversy. However, if all that it contains is all there is to be said, or if there is nothing to be added regarding methods that might be an improvement on those described, it would now be time to adjourn this meeting.

In his description of methods for transporting pulverized coal, he describes what he calls a continuous process by which it is forced through pipes of size ranging from 8 to 16 inches in diameter, from which branch lines lead to points where it is consumed. As a fan is used for forcing the coal forward, it must be assumed that air combines with the coal and passes out of the transfer pipe along with the coal at the point of delivery. The size of pipe used in this method, with the air pressure being low, it is possible and probable that the coal will adhere to the pipe, gradually building up until the section would show a ring through which the coal traveled. This being true, spontaneous combustion could occur

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*Mechanical Engineering, 1921, v. 43, pp. 321-322, 326.
†Safety Engineer, Carnegie Steel Co., Youngstown, O.

within the transfer pipe, and might travel forward to the point of discharge where damage could be done. This method would be better if a pipe of smaller diameter were used—say four inches—in order that the velocity of travel would be great enough to avoid adhesion to the pipe. It is not necessary to use a fan for delivering, as it can be done with compressed air by admitting it at the top of the scale or stock bin, at a pressure of about 45 pounds, this pressure acting on the coal as it would on water, forcing the coal out at the bottom of the bin without mixing with it. In cases where 20,000 pounds, in a single transfer, have been sent through a four-inch pipe 1200 feet long, the initial pressure was 45 pounds and this decreased to zero as the final quantity passed out of the bin. No air need be allowed to follow through the pipe unless it would be desirable to blow enough through to empty it entirely. Such amount of air as might follow the last discharge of coal into the container at the point of consumption could not create a hazard, as there would be no likelihood of a fire in the container to cause ignition.

A system such as just described for transferring, has been discussed, where the coal would be used direct from the line in the furnace. With a burner such as we have seen in use at the Follansbee Sheet and Tin Plate mills, there could be no possibility of fire getting into the transfer line. With such a system, a drop at the point of consuming, having a large diameter, sufficient for storing a quantity that would be a supply for a period during which some slight delay might occur, could be supplied.

In the method Mr. Tracy describes as indirect, where a Kenyon pump, which is a screw feed, is used for initial movement of the coal, and further acceleration is obtained by injecting air at the discharge end of the pump, the air, in cases with which we are familiar, is admitted through a regulating valve at a pressure of about 15 pounds. Secondary air is supplied by means of a fan. What seems to me like an ideal system would be to use the compressed air system herein described for putting the coal through transfer lines, leading from the pulverizing plant, and use the pump system between stock bins at points for consuming and the furnace it is consumed in, if it is not used direct from the line.

In regard to moisture accumulating in bins when they are set outside of buildings or out in the open, we can cite a case where bins under roof but exposed to temperature changes of weather, not being inclosed, have had pulverized coal in them since last June and moisture has not collected in them; neither has spontaneous combustion occurred. Investigation shows that coal leaving a Raymond pulverizer at a temperature of from 160 to 180 degrees, will reach the storage bin with a temperature of from 140 to 160 degrees. This temperature is reduced to approximately 80 degrees when it reaches the bin at the point for consuming.

In one situation we have in mind, fires have occurred in storage bins at points for consuming and neither of the causes—backfire through burner, or diverting of the blast from the fan supplying secondary air back through the discharge opening into the bin—was responsible for the ignitions.

While there is no denying that there is considerable danger connected with handling pulverized coal, there is no reason for saying it cannot be handled more safely than combustible gases can. The fact that it is not as liable to ignition as gas under ordinary methods of handling, has disarmed caution, and this in turn has been responsible for about all the serious accidents that have ever occurred when pulverizing or handling it. All the principles involved in igniting it where damage can result are well known, but the failure to ignite many times when conditions are nearly similar to what they are when ignition will occur, develops the belief that the ripe conditions are not likely to be present, and this aids in disarming caution. Without doubt in a perfectly constructed pulverizing outfit, where all the best appliances and methods so far developed are employed, coal can be pulverized and handled without accidents. Because the process does not necessarily exert pressure on piping or containers, the importance of providing such piping and containers as can easily be made tight and kept free from leakage, has not always been considered.

Investigation of the various methods for pulverizing coal and handling and consuming it after pulverizing, leads to the conclusion that it should be done in accordance with standard fixed methods so far as they can be made applicable to all existing conditions. In addition to these standard rules, special rules or methods should be adopted such as will fit each local condition. Every part of the equipment should be made so rugged that ordinary mishap would not cause leakage. Ruggedness should be considered, too, where parts are affected by abrasion, and such equipment as is least liable to deterioration from abrasion should be employed.

Spontaneous combustion probably does occur where accumulations of coal are allowed to remain in containers for a long period of time and some contributing cause for rise of temperature exists. It has been found that with some kinds of bins for storage, the coal will adhere to the walls in the angles, and this building up will extend until one or more sides of the wall are covered for a considerable area, and the formation will be exceedingly dense. It will adhere so tightly to the walls that, in some cases, it cannot be jarred off by hammering on the outside. Bins should be built without angles, and joints should be welded. Means should be provided for sweeping the interior of bins without opening them, to prevent incrustations or to remove them when they do occur. The capacity of holders should be kept reasonably close to actual requirements in order to avoid storing, as much as possible, for protracted periods of time.

Where pulverized coal is used in heating furnaces, the product of a pulverizing plant should be consumed in a diversity of ways, like generating steam, etc., in order that the accumulation necessary for ordinary requirements may be consumed when furnaces or other principal methods of consuming have shut down. An approach toward the ideal method of preventing pulverized coal from remaining in local bins, would be a system for transferring it again to some other point of consumption, such as boilers. Such methods for transferring should be employed as will tend to avoid mixture of air with coal, particularly hot air or gases, after the coal has passed through the drier and has been deposited in storage bins. This can be accomplished by admitting compressed air into the scale bin, or by the use of a pump which is only a worm, and is aided by admission of a small quantity of air under some pressure at the discharge end of the pump. It seems like a good idea to discharge the coal into "Cyclone" separators instead of the bins below the separators. Piping not exceeding four inches in diameter is sufficiently large for transferring from storage bins, and this size is less likely to choke up or become plugged than is a larger size.

While strict attention should be given to the removal of all accumulations of pulverized coal that settles within the pulverizing plant, prevention of escape of dust at each and every point in the process, beginning at the crushing machinery, including drying and pulverizing, is most important. Buildings should be strictly fireproof. Flooring and stair treads above the main floor should be of checkered bar construction so that all dust will precipitate to the main floor. Ledges at windows or other places should be avoided. If buildings have structural frames, covered with metal sheathing, the sheathing should be inside the frame. Preferably, the inside of buildings should be smooth brickwork, concrete work, or plastered walls, and whatever it may be it should be kept white by painting, in order that accumulations of coal may be visible.

The crushing plant should, so far as possible, be isolated from the drying plant by distance or by walls. The drying plant should be isolated from the pulverizing and transferring plants by walls. If practicable, drying furnaces should be isolated by compartments or outside location. All parts of electrical equipment, particularly switches and control boards should, where practicable, be isolated by compartments and outside location. Bins at places of consumption should be as remotely located as practicable from furnaces or combustion chambers.

Drying systems should be constructed and supplied with appliances so that temperature within predetermined limits can be absolutely maintained. Recording instruments should be so installed that they will be in direct contact with the heat current instead of heat in some isolated location, radiated from the heat current. Where pulverized coal is used in a drying furnace, temperature can be controlled by attendants with but a few changes of regulation, the same as with gas. Recording gages should be located where someone constantly in attendance can see them, and electrically operated instruments should be supplied for transferring the dial records to remotely located charts where someone is constantly in attendance to view them. Short angles in piping and curves with short radii should be avoided.

A signal system or means of communication between the pulverizing plant and points of delivery should be installed. Coal should never be forwarded except on order from the points of delivery, and an attendant should be employed to control the forwarding of coal at the delivery end. The equipment should be so constructed that attendants can shut off the flow of coal if necessary before bins are too full. Coal should not be delivered in a bin if combustion is going on within the bin. After a shut-down period of any considerable length of time, coal should not be delivered in a bin until such as may have been in the bin at the time of shut-down has been consumed.

Coal should be fed into the burners by a system that will give the desired addition of air at no other point than in the burner. There are numerous designs of burners as well as methods of burning, to do this economically and produce the desired temperatures, and burners should be of such construction that the coal cannot burn within them to form a coke that will interfere with free flow of coal and air.

Preferably, alternating current should be used for driving motors, and no other than squirrel cage or completely inclosed motors should be used. All wiring should be run in conduits, and drop cords should be used only in cases where they are absolutely necessary for the avoidance of open lights. All lamps should be guarded with substantial wire cages.

Crushing, pulverizing and storage buildings should be abundantly supplied with windows at various elevations, particularly in the upper regions. Means should be provided for conveniently opening and closing windows, in order that they may be changed to suit the changes of wind currents and secure the best ventilating results. As far as possible, they should be kept open when operating.

MR. HARVEY ALLEN: As to the question of dispensing with the drier, I believe it is possible, where you have air separation at your pulverizer, to pulverize without drying, but you dry the coal in your pulverizer, if you don't do it in the drier. Wet coal in the pulverizer will dry to such an extent that the air will lift it.

At the Erie City Iron Works I saw a method of using pulverized coal which pulverized the coal directly and fed it right into the furnace and they did not use a drier at all—simply pulverized coal and fed it right in. They had air separation, also showing the possibility of dispensing with the drier, but I think you would use up a great deal more power to dry it in the pulverizer than power and fuel to dry it in the drier.

MR. L. D. TRACY: Have you seen the installation of the Allegheny Steel Company, at Brackenridge?

MR. HARVEY ALLEN: No.

MR. J. R. CLINE:† Has the vacuum system been successfully applied to cleaning motors?

MR. HARVEY ALLEN: I thought it could be successfully applied to cleaning motors and I recommended that we put in one for that purpose, but for some reason or other, we did not make a complete success of it. We used compressed air to blow the dust out of the motors and had a big suction horn to suck the dust in attached to the vacuum cleaner. The vacuum cleaning system in the pulverizing house is quite similar to the vacuum systems in hotels; operated by motor with a piping system running up to the different floors and anywhere you wish to use it. A suction hose can be attached.

MR. J. R. CLINE: Have you had any experience in regard to handling fires in bins?

MR. HARVEY ALLEN: It is generally understood by the people who manufacture driers that if you catch the fire soon enough, it can be put out with fire hose and water. In most driers there is a place provided for a hose; but if the fire were to go under the drier until it was red-hot, which might happen pretty quickly, it would not do to put the water in there at that time. Putting water in will certainly extinguish the fire. When you do get the drier cool enough to put water in it, that will make sure that you do not have any fire in there when you start it again. I have heard that steam, if put into a drier, is a very effective and safe way of putting out a fire.

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†Mill Practice Man, Universal Portland Cement Co., Universal, Pa.

As to fire in the pulverized coal bins, that is pretty bad business and I cannot speak from personal experience. However, there are different systems of handling it. About the only one I ever knew of being successfully carried out was to take the coal out of the bin as soon as possible after you discovered the fire, let it lie in a pile for a while outdoors, and you may be able to get the fire out; then put it through the pulverizer again, run it out, and use it.

MR. J. R. CLINE: In a case of a bin containing powdered coal, you say get the coal out immediately. The only way to get it out would be through the burner feed screw or by disconnecting it. The minute you disconnect it, the coal-dust would come out in clouds and would be very liable to flash.

MR. HARVEY ALLEN: It looks that way; still they do take the coal out. I know of one case where they had a fire. They took the coal out of the bin, put it in a pile and after a while the fire smoldered out.

MR. WALTER GREENWOOD: In discussing the methods that should be followed for lowering the explosion hazard, when it is discovered that combustion is going on within storage bins at the furnaces, we find that some persons keep adding coal in order to keep the burning coal entirely covered. While the hazard may be considered, this is usually done to avoid delay and disagreeable labor connected with cleaning out bins. I do not think such practice is good, yet I know it has been recommended and followed.

MR. W. O. RENKIN:* As regards omitting the drier from powdered coal preparing plants, this has been done in some cases when moisture in coal as received is very low but it is one of those things that you can easily figure on as a loss in efficiency of the coal. Putting the coal in a drier and reducing the moisture content to less than one per cent. has been found to give the best results. When you have more than one per cent. in moisture you are losing money by burning out the extra moisture in the furnace.

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*Manager, Engineering Department, Quigley Furnace Specialties Co., New York.

Fires in the driers do not occur very often, as in present day installations methods of short-circuiting the drier when it is shut down eliminate most of these. By putting an auxiliary stack on the drier furnace, having its damper connected with a solenoid in such a way as to open when the drier shuts down, fires may be prevented. When the drier fireman builds up a large fire in the drier furnace, and then goes to sleep, you are bound to have burning coal come out.

I have some samples of powdered coal that has been stored in bins for 10 years and it has not burned yet. I have also seen powdered coal put in the bins Saturday evening when the plant shut down and by Sunday evening it was on fire. This was a very high volatile cannel coal. Another plant shut down on the fifteenth of the month, having bins about half full, and started up in two weeks without any sign of fire. This was a fairly high volatile coal.

MR. J. R. CLINE: I know of good driers with by-pass, but in just the case you mention of gross neglect by the fireman, what are you going to do?

MR. W. O. RENKIN: That is the human element which you can not get away from. I have been out in a plant where the men were properly instructed in firing of the drier and on a second visit two weeks later found the men back at the old tricks. In one case, they had built a bevel along the wall so they could fill the drier furnace up full and then go to sleep. The recording pyrometer or theremomoter is, of course, a check on this but when the powdered coal is wet and you get after the drier fireman he always says he is running the drier at the "right" temperature.

You can dry coal at a low temperature by taking out the moisture with a large volume of air, or you can drive it out with heat. The successful drier fireman watches his fires and the pyrometer chart at same time, checking his coal dryness with his hand as it is discharged from the drier. When the coal is received very wet he naturally slows down his feed and when it is somewhat drier the feed can be increased.

MR. L. W. MARSO:* We have heard a very good paper from Mr. Tracy, and as a manufacturer of powdered coal equipment I would like to make a few remarks.

One point was that in a direct or circulating system, we should always maintain a pressure on the intake side of a booster fan. This, I believe, would be impossible. If you had pressure there I should think you would fill it with coal. But you cannot maintain a positive pressure there, as the fan always exerts a certain pull on the intake line if it is discharging its air at higher pressure and volocity than it receives it. If there is always positive pressure there what would be the need of a booster fan?

Another point mentioned is that of shutting down a drier with coal in it. There is a very simple means of controlling that —that is, to provide an auxiliary stack to your drier fire-box and, on shutting down, by-pass the hot gases. We do this, and can allow coal to remain there for a month if we wish.

Aside from these points I think this paper a very interesting and instructive one, and I hope it will lead to improvement in the use of powdered coal.

In conclusion I would like to hand to Mr. Tracy a copy of some points that were brought up by us before the Industrial Commission of Ohio, at a meeting at which most of the manufacturers and many users of powdered coal equipment were present. There this subject was thoroughly discussed and I understand it is the intention of the Industrial Commission of Ohio to issue a code to control the design and installation of powdered coal plants. I only wish every state would follow suit, for after devoting several years of my active life to the powdered coal game I feel it time that somebody does standardize these installations to a greater or less extent; and I for one, will surely welcome the day when we can assure you good intelligent design and drive out some of the irresponsible and haphazard use of this fuel that has taken place heretofore.

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*District Manager, Quigley Furnace Specialties Co., New York.

MR. J. R. CLINE: Can any one present give an empirical figure that can be used to figure space required in a combustion chamber to burn pulverized coal thoroughly under a boiler or where flame is going against a cold wet substance; for example cubic feet of combustion space required for pounds of pulverized coal burned per minute.

MR. L. W. MARSO: That is rather a broad question. I do not know, as I have never found two places where the requirements were exactly the same. I have had quite a wide experience with furnaces, and in one plant I recall, where they had 88 furnaces supposed to be identical, they had variations. These were puddling furnaces which have been built in the same way for the past sixty years and yet the puddlers claimed that no two furnaces in the plant worked in the same way. That was their stock excuse for a turn of two or three heats when they were supposed to get five. However, I believe it depended more on their physical ability in those days.

It is hard to determine the exact combustion space required unless we have full and complete data as to what is required in the operation.

MR. L. D. TRACY: I cannot agree with Mr. Marso's criticism in which he states that it is impossible to maintain a positive pressure on the intake side of a booster fan when used in a circulating system. However, for the sake of argument, granting Mr. Marso's contention that a booster fan "exerts a certain pull on the intake line"—if that be true, the booster fan most surely is a menace, because then it is exceedingly liable to obtain part of its supply of air through the coal feed line to the furnace; and, in doing this, to draw back some of the hot coal particles into the circulating line. These hot particles will, in turn, ignite other particles of coal in the circulating system so that, in time, either a fire in the circulating line, or an explosion will ensue, depending upon the mixture of air and coal dust present in that particular part of the line.

THE POSSIBILITY OF IMPROVED METHODS OF ROLLING SHEET STEEL

By SUMNER B. ELY*

Probably the first iron plates were made by hammering and must indeed have been a crude production. About the year 1725 or 1730, however, rolls seem to have come into use, although it was a number of years later before anything resembling a thin sheet was made; yet from that day to the present time the same general type of machinery has been used for rolling sheet steel. To be sure, our sheet mills of to-day compared with the early ones would appear giants in size and strength; yet, after all, what real difference is there except this increase of size and strength? Why have we no automatic mills to turn out sheet steel, or at least automatic devices to reduce labor? This is the question asked by everyone who is familiar with the machinery and methods used in the manufacture of heavier steel products, such as billets, bars, rods, plates, etc. We have no continuous sheet mills, we do not even use roller-driven tables, automatic guides, etc. Practically everything is done by hand.

This statement may need a little qualification. Occasionally we do come across some small devices in use; such, for instance, as a hinged or pivoted table to assist the catcher in returning the pack over the top of the rolls to the roller. This particular device does not save any labor in the sense of fewer men being employed; it is merely a help to the catcher. Some devices, such as shifting tables and auxiliary attachments to cold rolls, may have a tendency to cut down the labor force; but, after all, such small helps as these are not real changes in the machinery of sheet rolling, and, furthermore, are far from being universally used. Many plants, probably most plants, do not use such devices; or, if they do, only an occasional mill in the plant is thus equipped.

It would seem, however, as if some device might be gotten up to cut down the number of men needed about a sheet mill. A mechanical catcher, for example, which would automatically catch the pack of sheets as it came through the rolls, lift it up, and return it to the roller. Such a device would seem to be a mechanical possibility and probably could be made to work successfully. Why has not some such device been worked out, perfected, and sold with each sheet mill as part of its regular equipment?

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*Professor of Commercial Engineering, Carnegie Institute of Technology, Pittsburgh.

There are probably a good many answers to this question, but it must ultimately come down to a matter of dollars and cents. What will the device cost and how much will it save? If the saving is enough, it does not make any difference what the attitude of the labor union is, sooner or later the manufacturer will introduce it, as has been demonstrated again and again in other industries. But the fact remains that such devices are not in universal use and it would seem as if the amount of saving was not sufficient to act as a real incentive. However, if the question of saving is in doubt in the case of improvements such as I have mentioned, there can be no doubt of a tremendous labor saving, if a successful continuous sheet mill could be devised. Somebody has made the statement, that any steel product, if enough of it is to be rolled and its size is uniform enough, must ultimately be made on a continuous mill. No other form of mill can compete; and this statement perhaps will come true of sheet steel some day. In the past, many attempts have been made and some very expensive continuous sheet mills have been built; and so, while there have been improvements in methods and practice, yet as I have said, the machinery is much the same as it was 200 years ago.

There is no doubt that to roll thin sheets of steel or iron is a most delicate operation and its success depends on many things. You occasionally hear a sheet mill roller say that the weather is not right to-day and he cannot turn out a satisfactory product; which simply means that some detail is wrong and he is unable to find what it is. One also hears stories from sheet mill superintendents to the effect that after having the windows of the mill cleaned, the rollers have trouble until they accustom themselves to judge the heat of the steel in the brighter light; and one can readily believe this.

In the manufacture of heavier steel products the temperatures to which they are heated are high, comparatively, and there is some latitude, but with sheet steel the heat must be just right. Even starting with the bar, say, as it comes from the furnace for the first pass in the mill, if it is too cold the scale will not be lifted and this scale rolls into the sheets, making a rough surface and causing the sheets to stick together later when they are rolled in packs. If the sheet mill could receive only bars that were perfectly clean, perhaps if the material were a little too cold no harm might be done, but all commercial bars carry scale and this must be taken into account.

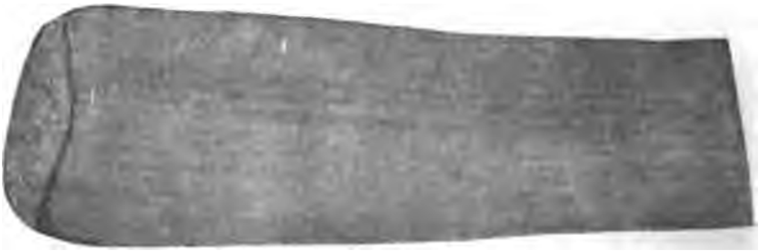

Fig. 1. Sheet with Round End.

However, if instead of the bar coming too cold from the pair furnace, it is a little too hot, there is still worse trouble. The large sheet rolls will get hotter than the roller anticipated, will expand, and the line of contact between them will not be correct; and, in addition, as the bar is too hot it will be softer than it should be, and will not spring the rolls the desired amount. The consequence of this is that the bar when worked down on the chill rolls will produce a sheet round on the back end—that is, thinner in the center than at the sides—whereas, probably the bar rolled before this had the proper temperature and produced a sheet that was not long in the center, but long on each side, having what the roller calls "horns." See Fig. 1 and 2. A round-end sheet indicates that the rolls are "full" in the middle and horns show that the rolls are "hollow." Now when a circular-end sheet is placed on the top of a horned sheet, reheated and put into the rolls together, the pack will either pinch or run off at the back end—that is, the sheets will spread one from another on the back end of the pack, due to the uneven drawing. And even if the roller, by great care and judgment in adjusting the draft screw, is able to prevent a pinch, the scale which is produced from being too hot will lift only in spots, sinking into the sheets and causing the pack to stick together in patches, so that the sheets cannot be pried apart without tearing.

Everyone familiar with sheet rolling realizes that the rolls must be kept at the proper heat so that they will be kept the proper shape to roll such a thin product successfully. A roller may (probably unconsciously) count on a certain spring to the stand of rolls, and by trial find the proper heat to go with it, so as to keep the shape of his rolls right; and he will watch carefully the size of the horns on each sheet as this is an indication of the shape of the mill. He knows that if he rolls too fast, and does not allow time enough between passes, his rolls will lose their shape. Neither must he roll too slow. Again, sheets always entered at the same place on the roll may cause trouble. He must constantly watch and guard against such things as cold drafts of air blowing on the rolls, and anything that will affect the temperature of the roll. Of late years some of these difficulties have been remedied by burning gas against the rolls to expand them when not in operation, or by blowing steam on working rolls to keep down the expansion.

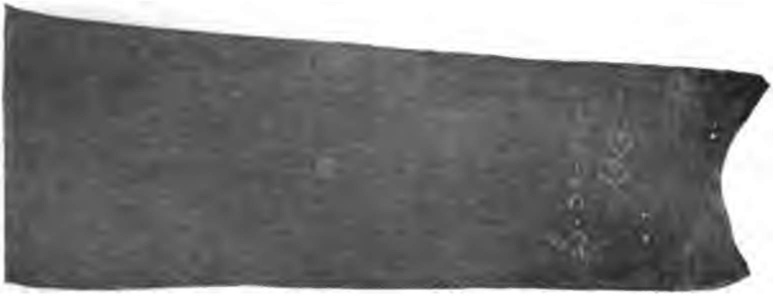

Fig. 2. Sheet with Horns.

Another most important factor is the roll-neck friction, and the extent of this is not always realized. For example, when finishing a pack, if one neck of a roll be greased (with hot neck grease) without greasing the other, the pack will always draw a long horn next to the neck that is dry. The reason is that the friction on the ungreased neck is greater and consequently heats and expands the roll on that side. Undoubtedly a large percentage of power is used in overcoming roll-neck friction. I have reason to think it is anywhere from 60 to 90 per cent. although there are no definite figures to go on. This is one of the most important things in roll design and yet we have no scientific

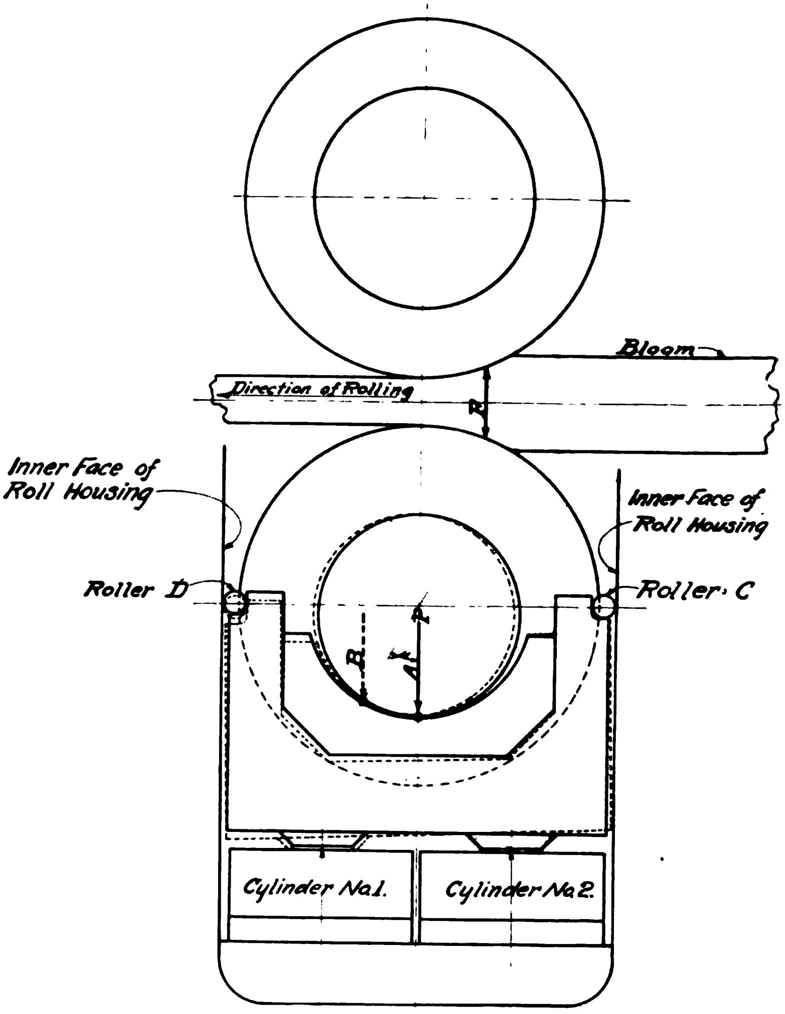

Fig. 3. Diagram of Hydraulic Support Cylinders.

information [illegible] radical changes.

Professor [illegible] nology has [illegible] which is arranged [illegible]

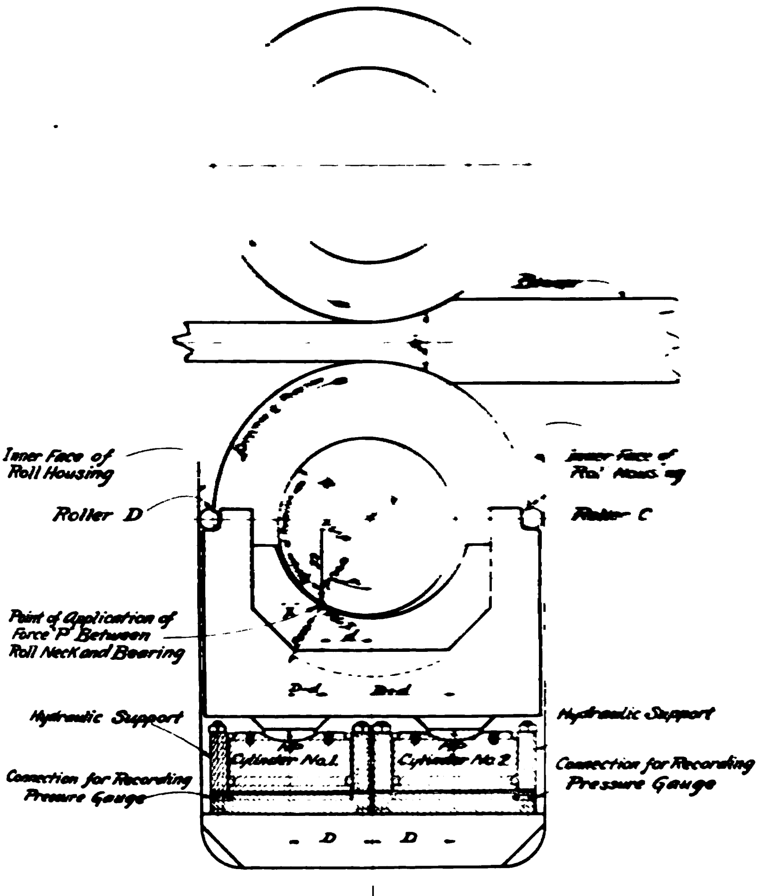
Bar
Inner Face of Roll Housing
Inner Face of Roll Housing
Roller D
Roller C
Point of Application of Force P Between Roll Neck and Bearing
Hydraulic Support
Hydraulic Support
Cylinder No. 1
Cylinder No. 2
Connection for Recording Pressure Gauge
Connection for Recording Pressure Gauge
D
D

Fig. 4. Analysis of Forces Acting on Hydraulic Support Cylinders.

ing can be controlled, and it is hoped that such a mill will be installed, for we are greatly in need of definite figures in connection with all steel rolling generally. He has kindly allowed me to show Fig. 3 and 4, which give the general arrangement he suggests for getting experimental pressures and other information on sheet mills. In Fig. 4 will be seen, underneath the roll and resting inside the housing, two hydraulic cylinders marked *No. 1* and *No. 2*. These two cylinders support the roll and, if the mill were standing still, would each carry one-half the weight due to the roll and its carrier. This carrier rests on small plungers in the cylinders, in such a manner that the forces acting on the roll neck are recorded by the resulting hydrostatic pressure in the cylinders. The full lines show this static position.

When the rolls are rotated the spreading force *F* due to the steel pinched between the rolls, will cause a heavy force *P* to be applied about as indicated in Fig. 4. This force *P* will be applied at some point to the left of the center as indicated. The roll carrier has a tendency to assume a position shown by the dotted lines in Fig. 3, this being shown greatly exaggerated for purposes of illustration. It is, however, vitally important that the bearing be perfectly free to rotate as indicated, and that no forces other than from cylinders *No. 1* and *No. 2* be interposed to prevent this rotating tendency.

Two rollers *C* and *D* are placed between the carrier and the sides of the housing; *C* acting as a fulcrum, and *D* having a tendency to lift off its seat. When a condition of equilibrium is established, it is possible to calculate the load, friction, etc., from a knowledge of the pressures in the hydraulic cylinders.

To anyone interested, I would say that there is a paper in the PROCEEDINGS* of the Engineers' Society of Western Pennsylvania, by W. B. Skinkle, at that time Director of the Bureau of Rolling-Mill Research, Carnegie Institute of Technology, in which will be found a description of this method, the system of forces, and how they can be calculated.

On hot-roll sheet mills at work, a blue or indigo color is often observable and this will correspond to a temperature of about 550 degrees F. This temperature will often run higher, although when reaching 750 degrees, showing a gray, the roll is liable to break shortly afterwards. In a perfectly dark room probably

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*June 1920, v.36. p.295.

900 degrees F. would give the roll a perceptible red color. Naturally, the roll is hotter in the center than at the ends and the necks are cooler for, although grease is often seen burning on the neck, the temperature at which the grease burns is generally lower than the temperature of the roll as indicated by its color.

In the history of sheet rolling there has been a tendency to increase the diameter of the rolls continually, until to-day sheet rolls of 30 inches are seen and I understand rolls as large as 32 inches have been used. The larger the roll, the more tonnage can be turned out, as a large roll does not change its temperature as readily as a small one. There is evidently a limit to the size however (aside from practical considerations of handling such heavy rolls), for the larger the roll the more the radiating surface to cause cooling (The fact that the volume varies as the cube and the surface only as the square of the diameter, has only an indirect relation to this problem of cooling). Also, the larger curvature will not draw the steel as much for the same total pressure.

As far as the breakage of rolls is concerned this is apparently due to unequal expansion, and not to the stress of rolling; as evidenced by the fact that rolls sometimes break when the roll is standing still, the roll train perhaps having been stopped for a few moments during the working period.

Considering now the possibility of a continuous sheet mill, it will be remembered that the United States Steel Corporation spent a very large sum of money at Farrell, Pa. A complete plant was built and in it was installed a continuous sheet mill which consisted of a series of stands of ordinary two-high sheet mills in tandem—the sheet passing through one stand after another, never being in two stands at the same time; and the sheets were automatically doubled and matched together in special devices at certain points in the train. This was about 1906 or 1907. It was thought, even if it were impossible to roll the lighter gages such as 26 and 28, that 18 or 20 gage could be successfully rolled. After this mill had been given a most thorough trial it was given up, the mill was dismantled, and the ordinary method of sheet rolling installed.

This is a convincing and definite proof of the great difficulties of sheet manufacture by using our present roll stands in a continuous train. Aside from any other question the difficulty of keeping so many different rolls in a like expanded condition and shape seems insurmountable. The present method of using gas and steam on the rolls which was not known at that time, might have aided a little; but something a good deal more certain than this must be devised if light gages are to be rolled in this manner. Possibly the heavier gages, say, 10 and 12, could be made in this way, but we already have satisfactory mills of a different type for this purpose and we would be no further along towards automatically rolling light-gage sheet steel.

Some method of absolutely heating the steel to a definite temperature—possibly some form of electric furnace—and some way of keeping the shape of the roll must be devised. Rolls have been cast with holes through the center and steam introduced or gas burned inside them; but they have been found inadequate to hold their shape and stand up to the service. The practice already mentioned of using gas and steam on the surface of the rolls is more satisfactory. Perhaps some day rolls will be placed inside a constant temperature furnace, but what would be done about the bearings and other details is a question.

Some twelve or more years ago I visited a continuous sheet mill in the town of Teplitz in Northern Austria. This is an extremely interesting mill and the only one of its kind I ever heard of. A plan of this mill is shown in Fig. 5. There are five stands of two-high continuous rolls, all being alike, having a diameter of 23⅝ inches and a length of 59 inches. In front of this is a small set of three-high rolls, and to the right a larger set of three-high rolls. An eight-inch slab is delivered to the large three-high mill and broken down to three or four inches in thickness. This slab is then cut in half and put into a reheating furnace, the furnace not being shown on the drawing. One of these halves then goes to the small three-high mill and is reduced to 9/32 of an inch (7 mm.) in thickness and then without reheating is put into the continuous stands. This thickness (9/32 inch) is always the same, and the reduction is varied on the continuous mill to give the required final thickness.

The sheet is finished about 60 feet long and is, of course, in all the stands at the same time. Sheets are always rolled singly and never in packs or doubled. They are from 40 to 50 inches wide. The stands are about nine feet from center to center and no idle rolls or automatic tables of any kind are used—simply stationary guides six or eight inches high and a cast-iron plate between the stands on which the sheet slides. The gear train gives the first stand rolls 30 r.p.m., the next 37.5, then 45, 52.5, and 60 for the last stand. When I saw the mill it was rolling a final product of 12 gage, making a total reduction in the five stands of some 58 per cent. (from 7 mm. to 3 mm.).

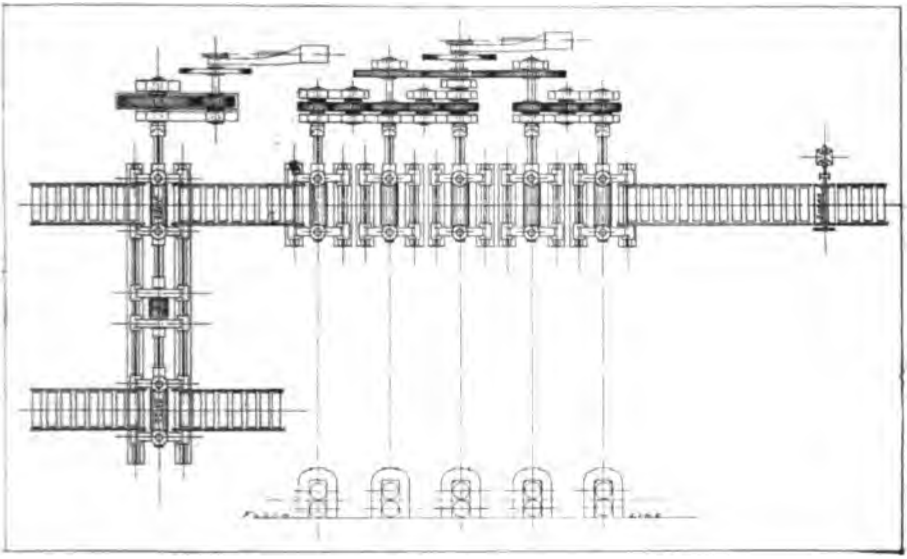

Fig. 5. Plan of Continuous Sheet Mill. Austria.

Several points of great interest present themselves in connection with this mill. The first is the fact that such a thin piece of steel could be in all the five stands of rolls at the same time and not either tear or be crumpled between them. Right here there is a great deal of confusion as to the pull exerted by rolls generally on steel and for this reason I want to digress for a moment. You will remember that a paper on the theory of the rolling-mill was read by Professor W. Trinks*, before this Society. In this he says: "Most people think that the steel is pulled through the rolls with great force. As a matter of fact there is little if any pulling action." This of course supposes the steel free and not held by any outside force.

Referring back to Fig. 4, you will note the vertical line *F* between the rolls and to the right of the center. Say that this represents the resultant of the various forces acting on the steel. Now, this line must be vertical; for, if it were inclined, there would be an unbalanced horizontal component which would cause acceleration, making the bar go faster and faster. As such an action does not occur this force *F* must be vertical. Therefore, if the speeds and drafts are correct among the various stands of rolls, the sheet will not "pull" itself to pieces going into the rolls—assuming of course that the shape of the rolls is also right.

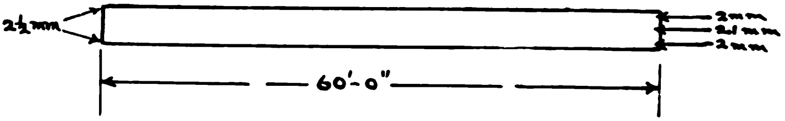

Fig. 6. Approximate Dimensions of Sheet Rolled on Mill Shown in Fig. 5.

This continuous mill has demonstrated the fact that not only can the shape of the rolls be controlled but the speeds and drafts among the various stands can be properly adjusted, at least for single sheets as thin as 14 gage.

Another point of great interest is the fact that the back end of the sheet comes out thicker than the front end, due to the rapid loss of heat while in the continuous rolls. The finished dimensions are about as indicated in Fig. 6. To work this mill economically it must work these long lengths and it is their practice to cut the 60-foot sheets into short pieces, and afterwards sort the corresponding thicknesses from the different long lengths together; so that the variation of thickness would not be noticeable to customers.

I was told that the mill was not a great financial success as there was not demand enough to keep running steadily on these particular gages. Furthermore, the engine running the continuous mill was about 1000 horse-power normal rating and totally inadequate to run the mill satisfactorily. They said they wanted to buy a larger engine but had no money. I never heard whether or not another engine was installed, nor do I know what happened to this plant during the war.

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*June 1920, v. 36, p. 275.

They had experimented very little with trying to roll two sheets in a pack. The furnace lay-out made it almost impossible to do so. However, the little that had been done seemed to show, as one would expect, that the thinner the sheet the greater the non-uniformity of thickness. It would seem that a reversing two-high mill, receiving alternately the hot and cold end of the steel might equalize this thickness and possibly be more satisfactory than the five continuous stands. So the question would naturally arise, what is the best way of rolling 12 and 14 gage. Then too, it would be impossible to take this 12 or 14 gage rolled on a special mill and finish it on the ordinary two-high sheet mill. Shapes of sheets and rolls will not fit and while one or two packs might be rolled with care, the scrap loss would be enormous and this has been tried commercially and failed. It has also been suggested and thought possible to reduce the cost of sheet rolling by starting with the product from a universal plate mill instead of a sheet bar mill. If a universal plate of seven or eight gage and of accurate width were cut to proper size it would be equivalent to doing away with some of the present roughing down process. However, when the price of the universal plate is taken into account there is little or no gain, and, in addition, the difficulty of doing good work has been very greatly increased.

Speaking of a reversing mill, at first thought it would appear that sheets might be successfully rolled in packs on a two-high reversing mill. The condition of the same two rolls in the same relation to each other and the same pack of steel is what we have in the commercial mill now; and certainly, with reversing roller tables, etc., a large saving in labor would result even if the tonnage per set of rolls were not increased. However, it must be remembered that in a reversing mill, first one end of the pack and then the other would be entered, and this thin pack of sheets would have to be first drawn in one direction and then in the opposite direction; and that the two ends of a pack are not alike. So that we really have a very different condition from the ordinary two-high stand.

This sheet machinery problem is a real problem, but to say or predict that a continuous sheet mill, for instance, is an impossibility, reminds me of my friend the physician who said: "A doctor should never tell a patient that he is going to die, because, you know, he might get well." And, while the outlook at the present moment is not encouraging, I am one of those who believe the solution will one day be found.

To my mind, the only logical way to approach this problem is from the scientific experimental side. It has been pretty well demonstrated that practice cannot furnish enough information. We need more knowledge of what actually occurs in rolling—what are the pressures, heat distribution, radiation, friction, etc. Who knows what per cent. of mechanical energy is turned into heat during a pass?

When enough data and information are at hand, new ways and means, as always happens, will be indicated. Our way of looking at the old facts will be different and from another point of view. Find out the underlying principles and causes first, and build elaborate experimental plants afterwards—not before, as has been the case in the past.

DISCUSSION

Mr. C. W. Bennett:[*] I did not come prepared to make any detailed comments on Mr. Ely's excellent paper. It is, to be sure, a very interesting subject and I agree with Mr. Ely that the problem of continuous rolling of sheets is quite subject to solution.

The experience that was had with the continuous mills referred to—first at the Monongahela Works, South Side, Pittsburgh, and later at the Mercer Works, Farrell, Pa.—indicates that the solution is largely a question, first, of proper design of mill, and, second, of the grouping of orders in sufficient tonnage. The mill at Farrell rolled 20 gage very successfully and the mill ran well on this gage. The trouble was that we had not had experience with numerous new problems that arose in designing the various component parts of the mill, and the result was that the mill was subject to frequent break-downs in the effort to get out tonnage. We did, however, produce a commercial tonnage of sheets of satisfactory gages and the mill was abandoned principally because there was no need of additional demonstration of defects in design, and because costs were high, due to frequent break-downs and interruptions in maintaining proper temperatures of rolls. I feel that a satisfactory continuous sheet rolling-mill will be built; in fact, plans had been made to build a mill shortly before the war broke out in Europe but they were abandoned on account of the war and there has been no opportunity since to proceed with these plans.

Mr. G. H. Cole:[†] In connection with this interesting subject I desire to ask a question concerning the influence of the rate of reduction in rolling upon the magnetic characteristics, and the efficacy of annealing in eliminating this effect. Sheets produced by rolling a bar down in five passes will probably have different characteristics from those made in 25 passes. Will annealing eliminate this difference?

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[†] Electrical Engineer Material and Process Engineering Department, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

MR. SUMNER B. ELY: I would rather refer that question to some one in the sheet and tin plate business who is more familiar with the subject. Mr. Pinkerton, can you answer it?

MR. A. PINKERTON:* In the manufacture of sheets for use in the magnetic structure of electrical apparatus the rolling conditions require careful attention, which would probably be very difficult to control in continuous mill operation.

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*Electrical Engineer, American Sheet & Tin Plate Co., Pittsburgh.

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TECHNOLOGY DIVISION
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VOL. 37 JULY 1921 No. 6

PROCEEDINGS
OF THE
ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

SOME TYPICAL USES AND PROPERTIES OF "MONEL" METAL - - - - - . *Edwin S. Wheeler and Robert J. McKay*
CALORIZING - - - - - - - - - *Arthur V. Farr*

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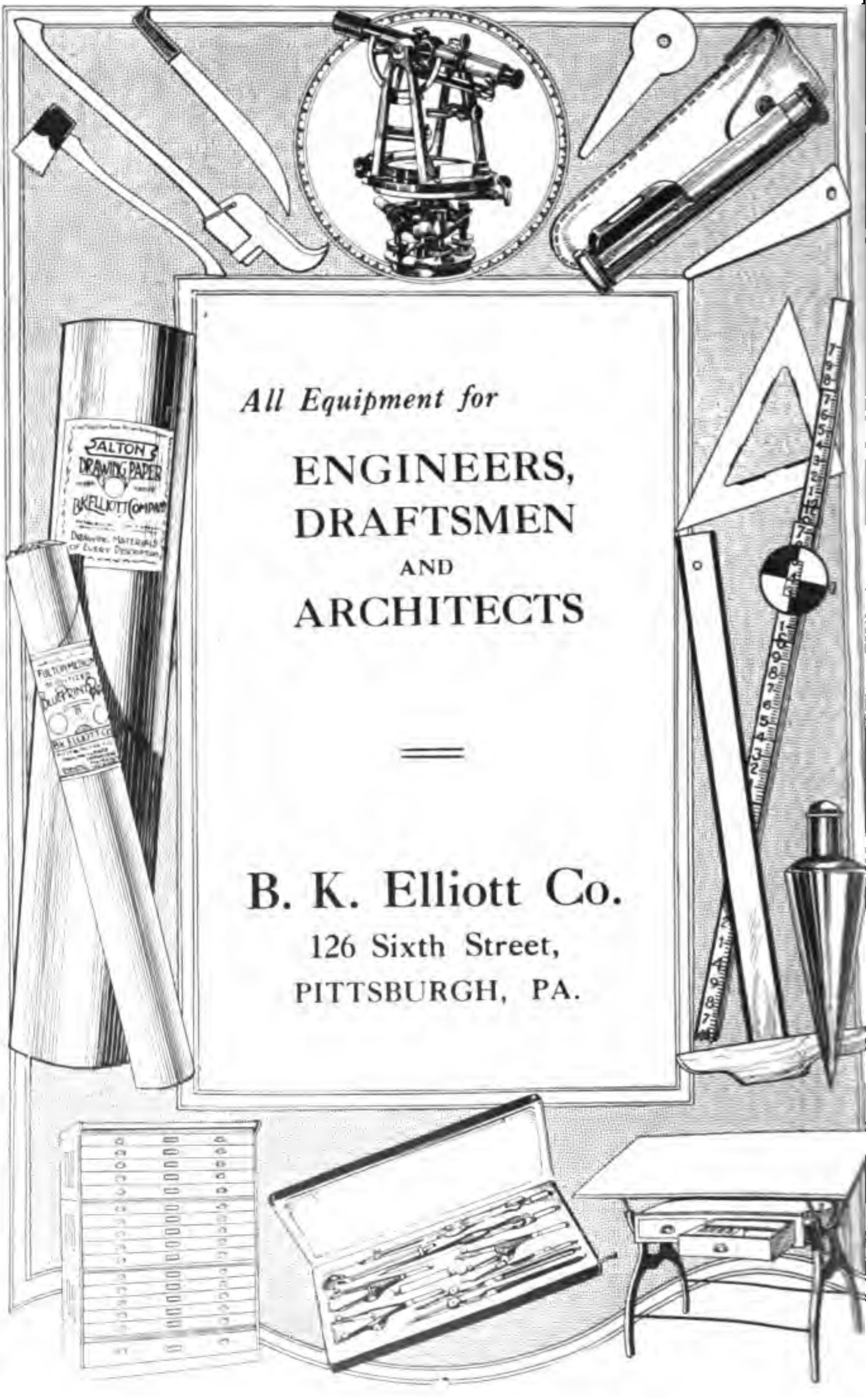

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SOME TYPICAL USES AND PROPERTIES OF "MONEL" METAL

By EDWIN S. WHEELER* AND ROBERT J. MCKAY†

"Monel" metal may be of interest to engineers from several different angles and perhaps a general description of its occurrence, properties, and uses may bring out points valuable to those entirely familiar with it in one or more of its separate fields as well as to those who have come into little contact with it and have only a cursory knowledge of its varied properties and uses. No attempt will therefore be made in the present paper to go into minute detail regarding the use in any field, but the more important typical uses and the properties valuable therein will be described. The occurrence and metallurgy will be discussed first; next, the typical properties in comparison with some of the generally known metals; third, the principal types of uses and the related properties; and fourth, special uses and the related properties.

Occurrence and Metallurgy. The ore from which "Monel" metal is produced occurs in the Sudbury district of Ontario. Lying northwest of the town of Sudbury is the "Sudbury Basin" of sandstones, slates, tuff, and conglomerates surrounded completely by a fringe of norite rock and then by the older granite formations. This basin is about thirty-six miles in length and sixteen miles wide and the nickel deposits in its vicinity constitute the largest known body of commercial nickel ores. Most of the commercial deposits occur at the contact between the norite basin and the granite surrounding it, and the most important are in the southern half of the rough ellipse described by this contact. The nickel occurs principally in viens of pentlandite cutting the pyrrhotite-chalcopyrite ores.

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The first evidence of the presence of nickel ore in the Sudbury district was found by an engineer of the Canadian Government, Salter by name, who noticed a local variation of his compass needle when running a meridian line near the position of the present Creighton mine from which the International Nickel Company produces the bulk of its product, and which is the largest producing nickel mine in the world. This was in the year 1856. Directly afterwards, Alexander Murray, a geologist, proved the presence of nickel in the large deposit of magnetic ore which had caused the deflection, but since the deposit was in a barren region a long distance from transportation routes, no importance was attached to the discovery and no attempt was made to develop the ores.

In 1883 a cut was made for the Canadian Pacific Railway, then being built, through the rock near the present Murray mine, and this cut uncovered a considerable deposit of ore. The adjacent land was bought by the Murray brothers of Pembroke, and was sold by them to H. H. Vivian & Company for the purpose of producing nickel, after later developments had shown the existence of commercial quanities of this metal in the ores. In the meantime, prospecting being stimulated by this discovery, the Copper Cliff mine was discovered in 1885 and the Creighton mine re-discovered in 1886. The first ore from the district was refined by the Orford Copper Company in 1887, being a shipment from the Copper Cliff mine. It was during the refining of this ore which was being worked for its copper alone that the discovery was made that the ore contained a valuable percentage of nickel. The metal showed itself first as it had to the old German miners as a "Devil of the Mine" (hence the name nickel), inciting the copper ores to bad behavior. After numerous tests the chemist of the Orford Copper Company showed that the trouble was due to the presence of nickel.

The copper and nickel were originally separated and it was not until about 1905 that the International Nickel Company left the metals in combination as they occurred and refined them to "Monel" metal.

The ore body of the Creighton mine is a lenticular mass as are most of the commercial ore bodies of the district. Mining was originally done in an open pit but as this became too deep for economical working it was replaced by shafts, the present one being about nineteen hundred feet deep. Ore is taken out through drifts and cross-cuts at various levels and is hoisted in skips to the bins at the top of the rock house—about one hundred and sixty-five feet above ground. It is crushed smaller than 5½ inches, hand picked on belts, the coarse ore sent to the roast yards for open heap roasting, and the bulk of the fines to the smelter. On the roast yard, which is over a mile and a quarter long, the ore is piled on cord-wood in heaps 100 feet long and 60 feet wide and the cord-wood ignited, thus setting the heap on fire. After a heap has burned about six months, one half of the 24 per cent. of sulphur has roasted off. The ore is handled onto the yard by a bridge and off into cars by steam-shovels. It then goes over the standard-gage railroad 12 miles to the blast-furnaces at the smelter. These furnaces are water-jacketed, rectangular, and about four by twenty-four feet inside. In them the roasted ore is smelted with 10 per cent. of coke to a matte of about twenty-five per cent. copper and nickel. This matte goes to the Pierce-Smith converters where it is wedded with matte from the fines which have been roasted in wedge furnaces and smelted in coal-dust fired reverberatories. The converters are about thirty-seven feet long and ten feet in diameter. In them the matte is blown to approximately 80 per cent. copper and nickel. It is now called Bessemer matte and is shipped to the Orford Works at Bayonne, N. J., for refining.

At the refinery, the Bessemer matte is ground in ball-mills and roasted with various additions in an Edwards-type, straight-line, roasting furnace to remove all the sulphur, and convert the metal completely to oxids. The "Monel" metal oxid thus formed is reduced with charcoal in oil-fired reverberatory furnaces and poled or flapped to adjust the carbon content to the proper value for the grade of metal to be produced. The tapping temperature is about 2850 degrees F. It is deoxidized with manganese and magnesium and cast in chill molds into ingots for rods, sheet, and forgings, or into blocks for remelting. The ingots correspond closely to those used in steel practice except that they are all top poured. Castings are made in sand or chill molds depending on the demand for the particular shape.

For hot-rolled sheets and for remelting, to the refined "Monel" metal is added about one-quarter per cent. of manganese. For regular rolling stock for hot and cold rolling and cold drawing of rods and strip, for gorgings, and wire, ferromanganese is added to give a manganese content of 1½ to 2 per cent. For producing castings "Monel" metal is usually supplied with additions of ferrosilicon to bring the silicon content to one per cent. or over.

Typical Properties. The "Monel" metal thus obtained is an alloy containing approximately 67 per cent. nickel, 28 per cent. copper, and 5 per cent. other metals—principally iron, managanese, and silicon with some precious metals. It is a single solid solution except for the possible presence of minute amounts of the oxids of manganese and magnesium between the grains. It can be cast, rolled hot or cold, drawn, or forged. It can be machined easily by using the proper precautions, welded with either the oxy-acetylene or electric spot- or butt-welding apparatus, soldered, brazed or polished, and in its working it resembles steel in many ways. It is annealed by heating to a temperature of 800 to 1000 degrees C., preferably in a reducing atmosphere where it remains until cool. It is hardened only by cold work. In its physical properties it again resembles mild steel to a certain extent. Its tensile strength, forged or rolled, runs from 75,000 to over 100,000 pounds per square inch depending on the amount of work and the finishing temperature. The elastic limit will be from 40,000 to 75,000 pounds per square inch, elongation 30 to 50 per cent. in two inches, and reduction of area 50 to 70 per cent. It is comparable to an annealed mild steel in hardness, its Brinell numbers running from 160 to 190. The Shore scleroscope is about 27. The elastic limit under compression is approximately 46,000 pounds per square inch.

Values for the torsional strength of hot rolled "Monel" metal have recently been obtained by a consulting laboratory.* These figures gave a maximum of 42,000 pounds per square inch, proportional limit, with a minimum of 19,000 for rods finished hot. The elongation of outer fibers was 450 to 300 per cent. and the number of turns at rupture, 21.5 to 3.25. Shear tests by another outside laboratory† gave, for double shear, 61,000 to 45,000 pounds per square inch.

A research laboratory in Great Britain‡ has recently made an interesting series of comparative Izod impact tests on several different metals and the position of "Monel" metal at the top of the list is worthy of comment. The metals thus compared were, wrought-iron, 0.75-inch rolled mild-steel rod, rolled brass rod, forged copper, rolled "Monel" metal rod, cast admiralty gun-metal, iron cast in green sand, and high-tension bronze cast in chill. The results are expressed in foot-pounds absorbed in breaking or bending and follow in the order of their magnitude:

Cast-iron	0.8
Admiralty metal	8.0
Rolled brass	23.0
High-tension bronze	25.5
Forged copper	46.0
Wrought-iron	58.4
Mild steel	76.7
"Monel" metal	113.7

All pieces were broken in the test except copper, wrought-iron, mild steel and "Monel" metal.

This high value for the resistance to impact seems a matter of course to one who has seen "Monel" parts subjected to sudden severe shocks which would be destructive to other metals of the same strength, for in these cases they have seen "Monel" metal only bent or distorted in such a manner as to require straightening to be again put into service, while other metals of similar or greater tensile strength were broken and ruined for further use. There was an interesting illustration of this some time ago on a

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*Electrical Testing Laboratories, New York.
†Fritz Engineering Laboratory, Lehigh University.
‡G. and J. Weir, Ltd., Cathcart, Scotland.

destroyer which came into a navy-yard with one of its turbines out of commission. Examination revealed the fact that a nickel-steel bucket had snapped when revolving at high speed and before the turbine was shut down all the other steel buckets were broken off short. None of the "Monel" metal buckets was broken in spite of the fact that steel buckets were wedged in among them in such a way as to bend them badly. It was necessary to replace the steel buckets with new ones while those of "Monel" metal needed only to be straightened.

The modulus of elasticity is about 25,000,000—about the same as wrought-iron and twice as great as brass. This comparatively large value is useful in the construction of such pieces of apparatus as propellers, where distortion may cause a great loss in efficiency.

The ultimate strength of sand-cast "Monel" metal is about 75,000 pounds per square inch, yield-point 40,000 pounds per square inch, and elongation 30 per cent. in two inches. The hardness is about 23 Shore, and 120 Brinell.

The tensile properties of cold-drawn or rolled wire, rod or strip, vary largely according to the cold work, degree of annealing, and gage. The ultimate strength may be produced from 85,000 to 150,000 pounds per square inch, yield-point 50,000 to 90,000, elongation 30 per cent. to 1 per cent., depending on the hardness, which may be as high as 45 Shore when heavily worked and not annealed. When annealed the hardness may be as low as 10 to 12 Shore.

The melting point of "Monel" metal is 2480 degrees F. Its specific gravity is 8.87 cast and 8.96 rolled—14 per cent. greater than steel. Its coefficient of expansion, between 70 and 212 degrees F., is 0.00000765 per degree—14 per cent. greater than steel and 18 per cent. less than copper. Its electrical resistance is 256 ohms per mil foot, and its temperature coefficient 0.0011 per degree F. Its conductivity, relative to copper, is four per cent. Its relative heat conductivity is 1/15 that of copper. The amount of shrinkage in cooling from the molten state is one-fourth inch per foot.

"Monel" metal is, perhaps, the best general metal for resisting attack by acid and alkali and resisting chemical corrosion in general. There are other metals, of course, which are more resistant to certain corrosive agents, but "Monel" metal—having a solution potential well below hydrogen and acid resisting metals—is, in general, attacked less seriously than any other metal. It combines with its slow rate of corrosion the property of corroding evenly with no pitting or local attack.

It withstands successfully such corrosive actions as that of atmospheric conditions, fresh or salt water, wet or super-heated steam, gases of combustion, metallic mercury, and the oxidizing influence of heat up to 1000 degrees F., below which point only superficial oxidation takes place. It has been used satisfactorily in connection with benzoic, citric, hydrofluoric, lactic, dilute phosphoric, picric (in the cold), salicylic, tannic, hydrocyanic, and carbolic acids. There seems to be sufficient evidence that it is resistant to all fruit and fatty acids and phenols. The action of foods is not severe on "Monel" metal and food may stand in vessels of it for some time without acquiring a foreign flavor. Tomatoes and clams are perhaps the only exceptions to this. They have been found at times to be so affected by long standing in "Monel" metal as to make them unfit for use.

Pure alkalis will, in general, attack "Monel" metal only very slightly. Some cases have been known, however, where alkalis in the presence of their salts have affected the metal, and it may be stated as a general rule that such mixtures will produce definite corrosion.

Principal Types of Uses and Related Properties. One general type of use is for structural purposes where it is subjected to severe weather conditions. This includes its use for roofing sheets, skylight frames, etc. The properties which enter here are its strength and its resistance to atmospheric corrosion. An example of this use is the roof of the Pennsylvania Terminal, New York, which is entirely of "Monel" metal and which has needed only minor repairs since it was built. Even the minor repairs were caused by faulty laying and not by any failure of the metal.

Another general type of use is for household, hotel, and hospital hardware, including trimming and fixtures where a bright, permanent, white polish is desired, other hardware, plumbing parts, cooking and serving utensils, table flat ware, and washing machines. These uses require that the metal be resistant to the action of foods, hot and cold, and to cleansing agents; also that it take and retain a good polish.

In regard to its use in hot water and superheated and wet steam, some very interesting data have been presented to this Society by J. Roy Tanner and George J. Stuart.* "Monel" metal has given good service in valve-seats, rings, bushings and stems, pump rods and plungers, meter parts, stop-cocks, etc. The improtant properties here are the retention of tensile strength at high temperatures, tensile and expansion properties similar to those of steel, and tendency to wear or corrode evenly, if at all.

Its resistance to oxidation and to gases of combustion at moderate temperatures makes it serviceable in equipment for oil combustion, spray valves, ignition points, welding-torch heads, conveyors and stirrers for furnaces, valves for internal-combustion engines, glass rollers and blowpipes.

Being resistant to many forms of chemical corrosion and, at the same time, of high tensile strength and impact and wear-resisting properties, it is used in chemical work such as pickling crates, pins, tie-rods, nuts and washers, evaporating and drying pans, Fourdrinier machines, filter cloth, textile machinery, and in handling of acids and chemicals in general.

Some Special Uses and Related Properties. Of particular interest in the Pittsburgh district is the use of "Monel" metal parts in the process of pickling steel sheets and bars in sulphuric acid. The metallic equipment for this work consists of crates, pins, hooks and bales, tank tie-rods, nuts and washers, and tank drains. The original cost of "Monel" metal for this work is greater than of most of the anti-acid bronzes which are used for the same purpose. However, the greater resistance of "Monel" metal to the acids and pickling agents, combined with its strength and resistance to impact and its amenability to re-working, make it cheaper in the final analysis. Judged by the loss in weight, the rate of corrosion of "Monel" metal in hot six per cent. sulphuric acid in contact with air, varies from about four milligrams per square inch per day to 15 milligrams per square inch per day—0.01 to 0.04 inches penetration per year, depending on the temperature, the rate of agitation of the solution and the conditions of atmospheric contact. The rate of leaded and phosphor bronzes usually referred to as anti-acid bronzes is from two to three times as great, and of the best aluminum bronzes approximately the same as "Monel" metal. "Monel" metal is at the same time stronger than any of these metals, is from 3 to 10 times as resistant to impact and is not subject to pitting. In the larger plants its forging qualities make it of especial value, as a part which has worn out in one place may often be re-worked for another purpose. The writer has recently inspected a "Monel" metal chain which was forged from pickle pins which had, in their turn, been made from corroded tie-rods. The electrolytic cells which are used in pickling practice, and which are an important factor in the deterioration of the metal, are comparatively less active on "Monel" metal than on metals containing higher percentages of copper. "Monel" metal is negative to (more noble than) practically all the anti-acid bronzes in sulphuric acid solution. The attack of the acid itself is very slow, compared with the above figures, at all temperatures in strengths of acid up to 20 per cent. From 20 to 40 per cent., the attack is more lively, and above this point it falls off again. The life of the metal in pickling equipment will, of course, vary with the conditions to which it is subjected—electrolytic effects, oxygen content of solution, acid strength and temperature—and may be from 2 to 12 years.

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*Proceedings, Oct. 1919, v. 35, p. 311.

If "Monel" metal is to be used where exposed to hydrochloric acid or its fumes, it should be subjected to a preliminary trial, as it has been found that in some cases it will not stand up while in others it withstands the action of the acid with entire satisfaction. The laws governing this action have not been thoroughly worked out. It is evident that local conditions and methods of handling have a great deal to do with its ability to resist this acid. It is, however, probably true that "Monel" metal will resist it better than any other common alloy. In no case is it recommended for nitric, chromic, perchloric, hot picric or hot phosphoric acids, or such oxidizing salts as ferric sulphate, copper sulphate, mercuric chlorid, or molten zinc salts. Neither will it resist molten metals or molten sulphur. It resists well the action of dry chlorin and the sulphur-laden gases of ordinary combustion.

Another important special use of "Monel" metal is in turbine buckets, especially for marine turbines. For land turbines, brass or bronze for the smaller high-pressure buckets, and nickel steel for the larger high-pressure buckets and all the low-pressure buckets, are often satisfactory; but where the pitching and tossing and twisting of boats in a heavy sea, operating contrary to the gyroscopic action caused by the high speed of the moving parts, sets up strains and stresses which would cause other metals to crystallize and snap off, "Monel" metal remains unaffected. Another factor in its favor for this work is its ability to retain a large percentage of its tensile strength and other properties at the temperature of the steam operating the turbines.

In power-plants its ability to retain its tensile strength at steam temperatures and to resist the erosion of live steam give it a large use. Valve trim and turbine shrouding are often made of it. Pump rods and liners in pumps that handle water containing a large amount of acid or other corrosive agents are generally of "Monel" metal. In hydro-electric power-plants large impellers cast of "Monel" metal are often specified. In the latter case, bronze has been discarded because the erosion of the water eats away and roughens the vanes. "Monel" metal is admirably suited to replace it because under such erosive action, instead of becoming pitted and roughened, it remains bright and smooth, thereby giving maximum efficiency.

Several years ago, Brezowsky and Spring of the Crane Company conducted experiments comparing "Monel" metal to other alloys for use in the valves made by the Crane Company for handling steam. All of these tests showed that "Monel" metal was better suited for their purpose than the other metals tested. It retained its physical properties better than practically any other alloy, and where this was not the case the difference was very slight. Its strength was either greater at corresponding temperatures, due to its greater initial strength, or it was more resistant to the corrosive and erosive properties of the superheated steam. These properties have been more recently verified in the laboratory of the International Nickel Company and in laboratories abroad. Tanner and Stewart, in the paper mentioned above, showed that for handling superheated steam the only satisfactory valve was one of cast-steel body with "Monel" metal mountings. It has been repeatedly compared with other alloys for this work and so far none has been found to approach it.

Besides its use on shipboard for pump parts such as liners and rods, and superheated steam-valves, it is used for trim on launches and larger boats. This is, of course, because of its ability to resist the corrosion of salt water and spray and to retain a polish under their action. Propellers of boats, ranging in size from the battleship *North Dakota* to small pleasure launches, are successfully used. In many cases the shafts which turn these propellers are also of "Monel" metal. Condenser parts such as ferrules, also rudders, struts, stuffing-boxes and innumerable other parts can economically be made of it.

Its heat resisting qualities, while not as good as the nickel-chromium or nickel-managanse alloys, are such as to make it well suited for certain heat resisting uses. It has been found, for instance, that "Monel" metal exhaust-valves in internal-combustion engines give excellent results. The United States Bureau of Standards has recently issued a report on this subject comparing "Monel" metal most favorably with tungsten steel. The tests were run using a 180-horse-power Hispano Suiza airplane motor as the testing medium. The valves were run for 130 hours under exceptionally severe conditions without regrinding, and at the end of that time there was no apparent loss in power from leaky valves. Grinding was apparently slightly detrimental to the metal of the valves. A feature which adds to its value in such uses is the fact that it is not subject either to pitting or to carbon deposits. It is successfully used for the electrodes of spark-plugs, where the heat is extremely intense at intervals, though it is not as good for this purpose as manganese-nickel alloys.

Other places where "Monel" metal has found a place in the automotive field are in carbureter parts such as the floats and needle-valves (because of its ability to resist the corrosive action of gasoline), dash trim, door and brake handles, accelerator pedals, and other places where it is desirable to retain a high nickel finish under severe wear. Spark-plug electrodes and ignition chambers of oil-engines are sometimes made of "Monel" metal, though these parts are more generally made of a special high-nickel alloy because of its greater resistance to the effect of the high heats that are generated in these engines.

In the mining industry, "Monel" metal is found well distributed in the form of pump rods and liners, mine screens, and coal chutes. In the latter case its ability to resist abrasion and corrosion has been the factor governing its selection. At the same time "Monel" metal should not be used in mines which have an appreciable amount of ferric sulphate in the water, as this salt has a decided corrosive action on it.

The ability of "Monel" metal to withstand the action of the weak acids and other corrosive agents of foods give it value in the handling and preparation of food products. Packing-house equipment which comes in contact with brine and salt is largely made of it. Meat and fruit slicing machines, canning apparatus, dairy machinery—such as butter handling machines, milking machines, separators, and pasteurizers—have parts of this metal. In the kitchens of some of the large, new, up-to-date hotels, "Monel" metal is prominent in the form of steam-table tops, coffee urns, pots, and pans.

A growing use of direct personal interest to many, is as a metal for the manufacture of heads for golf clubs. The use of "Monel" metal heads does away with the necessity for grinding and polishing to keep them bright, and these heads will not become lighter with use. There has been some argument as to whether or not they give a greater distance to the ball than steel heads.

Experiments are being conducted in New York City to determine the suitability of "Monel" metal for parts in telephone and telegraph subways. Here the metal parts are subjected to seepage from the sewers and to the filthy salt water that often fills the subways along the water front. These waters are exceedingly corrosive. Ladders for the manholes, locks for the covers, and similar parts have been made of "Monel" metal for trial. To date, these parts have been in service for nearly two years in the worst manholes in the city and are as good as when put in, while parts made of other metals have lasted, at best, only a few months.

Because of its extended use in contact with salt water it may be interesting to say a few words on this subject. Salt water in itself has no corrosive effect whatever on the metal; but, in spite of this fact, some trepidation has been felt by the International Nickel Company regarding its use in this connection because of the strong electrolytic action which is set up at times between "Monel" metal and other metals adjacent to it. This action is the result of two contributing factors—first, its very low solution potential, it being well under that of most of the other common metals; and second, its tendency to maintain a clean surface, which means a surface which does not polarize readily. This electrolytic action is usually not at all detrimental to the "Monel" metal but will seriously affect the other metal present.

An interesting case of this is that of the yacht *Sea Call.* The hull of this vessel was made of "Monel" metal plates. A cast-iron stem and stern and a few steel rivets were used. A short time after being put into commission she began to leak badly and after a few weeks of service this leaking was so serious that she was taken out of the water for an examination. It was then discovered that the steel rivets were entirely eaten away by the electrolytic action, while large holes were found in the cast-iron stem and stern due to the same cause. Some of these holes extended completely through the castings and weakened them so much that it is doubtful if the boat would have held together for more than a few days longer. But there was no sign of corrosion of the "Monel" metal plates. Of course, the *Sea Call* had to be scrapped, and "Monel" metal for marine construction acquired, as a result, a bad reputation which persisted for some time in spite of the facts in the case.

If "Monel" metal is to be used with some other metal in salt water the necessary precautions are simple. The United States Navy uses a good deal of it under water in propellers, outboard submarine fittings, and similar places. In the case of the propellers a steel shaft with manganese-bronze sleeve and cast-iron steel brace is used. On the brace is placed a piece of zinc which protects both the brace and shaft as the electrolytic action attacks the zinc first. Whenever the boat goes into dry-dock a new piece of zinc is put on. Another effective method of protection, where it is possible, is to insulate the two metals by placing rubber or gutta-percha between them.

Summary. Some of the other interesting places (which are too numerous to discuss in any detail) where "Monel" metal serves a special purpose may be mentioned in closing. Parts for ordnance and for submarine construction, incinerator machinery, sewage handling machinery, lavatories, textile machinery, storage-battery casings, burning points and racks for enamel ware, plugs and other parts in the manufacture of gasoline in Burton stills, oil-handling machinery, parts of tempering furnaces, valve-stems on high-pressure fire hydrants, tank linings for acid and alkali, gas-engine water-jackets, chain to resist weathering, wire rope, sash-cord, resistance wire, rivets and nails, dyeing machinery, refrigerating machinery, and sugar refining equipment.

It must not be felt that "Monel" metal is a "cure-all"—the best material for meeting every set of difficult conditions. In many cases, the result of its use will be inevitable failure. On the other hand, widely varied successful applications demonstrate its value as an industrial material. From what has been said, it can be seen that this metal touches us at widely different points, both in industrial operations and in our daily life. Its varied uses—turbine blades to golf heads, filter cloth to food containers, marine propellers to pickling pins—have been developed because it answers the need so strongly realized by the engineers of to-day for a material combining efficiency and high ultimate economy.

DISCUSSION

Mr. M. R. Walton:[*] The speaker mentioned the remarkable corrosion resisting properties of "Monel" metal, but said later that iron sulphate has a corrosive influence. I wonder how the metal would be affected by pickling solutions.

Mr. Robert J. McKay: The salt which has a corrosive effect on "Monel" metal is ferric sulphate. In pickling solutions, the iron in solution is always in the reduced or ferrous form, and in this form will not attack "Monel" metal. Such an attack will occur only when it is oxidized to the ferric form.

Mr. A. C. Fieldner:[†] One of the important needs in the mining industry is acid-resisting parts for pumps. Mine water contains ferrous and ferric sulphates, and free sulphuric acid. It is very unfortunate indeed that ferric sulphate has a corrosive effect on "Monel" metal. I would like to ask the speaker whether it requires a very large concentration of ferric sulphate to corrode this metal, and if he has any data on the use of "Monel" metal parts for liners and rods for pumps that are handling mine water?

Mr. Robert J. McKay: I would say that almost any appreciable amount of ferric sulphate will attack the metal. It is unsafe to use "Monel" metal parts where ferric sulphate will show up in analysis. "Monel" metal may be used if there is a reducing element present but it should not be used in the presence of an active oxidizing salt. It has been successfully used in mines in many cases but as a general rule it is better to make a test with the particular mine water before installing expensive apparatus. The data on pump fittings for mine water is contradictory and depends on the mine.

Mr. W. J. Merten:[‡] As I take it, "Monel" metal is a natural product. I want to ask whether any attempt has been made to vary the proportions or nickel and copper with the idea of eliminating some of the objectionable features, and whether the addition of other metals will not remove some of these objections?

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MR. ROBERT J. MCKAY: The International Nickel Company is carrying on an extensive research program and one of the principal problems is that of the properties of "Monel" metal and its alloys. Tests are constantly being made of the effect of using various alloying metals. No very extended tests have been made on changes of copper and nickel content because the metal can be more efficiently made as it occurs and preliminary tests have shown this to be rather an unpromising field for study. However, the problem is being considered at all times and the International Nickel Company is open to reasonable suggestions from any source.

MR. W. J. MERTEN: Was your Izod impact value of 129 foot-pounds obtained from a standard V-notched test-bar of one square centimeter?

MR. ROBERT J. MCKAY: Yes, this value was obtained with the standard notched test-bar.

MR. F. F. ESPENSCHIED:* I know a gentleman who uses "Monel" metal for high-pressure steam-valves, and for his purpose he has changed the proportion of nickel and copper. In fact, he reports better results by reversing the nickel-copper ratio. Is it not reasonable to suppose that other ratios, different from the natural or native ratio, may be better for many purposes? It would appear that this field offers an opportunity for a lot of experimental work. Alloy steels have had a remarkable development; why not nickel-copper alloys?

MR. ROBERT J. MCKAY: Various copper-nickel alloys are quite widely used and the general properties of these alloys fairly well known. The research department of the International Nickel Company has not been able to see any great value in changing the copper and nickel contents of "Monel" metal. However, if it is so that for this particular purpose changes in the copper-nickel ratio are advantageous, the information is of much interest, and I would be glad to have further details of the tests. It has been our experience that there is no better metal than "Monel" metal for use with high-pressure steam.

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*Pittsburgh District Representative. Commercial Truck Co. of Philadelphia, Pittsburgh.

MR. L. GERALD FIRTH :* I have received a letter from Sheffield recently stating that it had been reported there that "Monel" metal could be hardened in a manner similar to steel so as to take and retain a cutting edge. Is this correct?

MR. ROBERT J. MCKAY: The International Nickel Company has been working for some time on the properties of aluminum-bearing "Monel" metal and is finding that it has some very interesting properties, among them a hardening effect which might make the metal suitable for cutting edges. Some reaction has been obtained from heat treatments but nothing to compare with the tempering of steel. The experiments have not progressed sufficiently to warrant the publication or dissemination of the results.

MR. M. R. WALTON: The speaker said "Monel" metal could be welded and that it would have a good structure. In case a welded rod is brought into contact with acid solutions, would it not be subject to electrolytic action?

MR. ROBERT J. MCKAY: The question of the importance of such electrolytic effects is debatable. There is no doubt that a weld—which means the presence of melted metal—will have a potential slightly different from that of a rolled sheet. Whether this potential will have an appreciable effect in promoting corrosion will depend on several things, among which are the relative areas of the different forms of metal and the electrolyte with which they are in contact. I have made some experiments on the corrosion of welds and in some cases have been able to corrode the weld somewhat faster than the surrounding metal. The ease with which this is done depends very largely on the method of welding, and I believe that, in cases where welds have failed, this is due to oxidation of the metal during welding rather than to the difference of potential of the two forms of metal. It is possible to produce welds which are nearly enough perfect to resist acids, but in doing so great care must be exercised to prevent oxidation.

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*Works Manaager, Firth-Sterling Steel Co., McKeesport, Pa.

MR. W. J. MERTEN: I should like to inquire as to the making of seamless tubes of "Monel" metal.

MR. ROBERT J. MCKAY: The manufacture of seamless tubes is a hard problem. The International Nickel Company has been working on it for years and up to the present time the manufacture of seamless tubes has not been commercially successful. The mechanical difficulties of piercing a billet are very great on account of the strength of the metal at high temperatures. The billet must be very hot and evenly heated and the heating atmosphere must be carefully controlled at this high heat. It is questionable whether a billet can ever be pierced economically.

MR. L. E. FROST:* I should like to ask the speaker if he has had any experience in plating "Monel" metal. It has been very difficult to get uniformly good results in copper-plating parts used on rotating machinery. The present practice is to nickel plate and then copper plate, and perhaps 10 per cent. of the straps will have very poor adherence.

MR. ROBERT J. MCKAY: I am afraid I cannot help you very much on that. I have had no experience in plating "Monel" metal as such a necessity is unusal. I do not see, however, any reason why it could not be sucessfully done, particularly with copper. Nickel and, of course, copper can be successfully plated, and "Monel" metal is intermediate in its electrolytic effects in contact with an electrolyte.

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*Engineer, Materials & Process Engineering Department, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Mr. M. R. Walton: The hour is getting late. I do not know whether to relate to an interesting experience we had, but, if the Society wishes it I will try to give it.

In January we met with some difficulties in plating; we were electro-galvanizing automobile rims and got copper deposit in the pickle. The plant had been operating eight years and our process of plating had never been changed, but we had never had any such trouble before. We were in great difficulty, because it was holding up our entire production. An expert on electrolysis came from Cleveland. We looked for about a week for the cause of the trouble, and changed various parts, until finally an iron rod was substituted for a "Monel" metal rod that was carrying the rims. The trouble was thus eliminated and after that time we held "Monel" metal responsible for the disorder. Our plating arrangement consisted of an overhead track and hoist with two strands of wire-rope fastened into a lift rod. This lift consists of 1½-inch, extra-strong pipe as a strut, with "Monel" metal bridles, and the material of the bridles was changed. This lift rod went down and took hold of what we call a work rod—a three-inch, extra-strong, bronze pipe. During the operation the rims in going through the process were first lifted up and put through a caustic wash and from there went into the pickling tank, which was lead lined. In the pickling solution we had steel rims, commercial brass or bronze pipe, cast bronze or brass collars, copper straps on work bars, and "Monel" metal.

In the investigation of the cause of the above trouble with the copper deposits we found that we generated half a volt in the tank. We also had something like 20,000 amperes generator capacity at six volts and discovered that our building was charged all over. To offset any electrolytic effect which might be caused by outside currents we changed the polarity of the lead in the tank and track, and then connected the bar to the generator until we got at least 100 amperes through the work. The changes in polarity did not have any effect on the deposit of the copper, and the discontinuance of the "Monel" metal got us out of trouble.

I would like Mr. McKay to give us his opinion on that case.

MR. ROBERT J. MCKAY: I do not see how "Monel" metal could have been the real difficulty there. Did you say that copper was deposited on the rims when you were passing a current of 100 amperes?

MR. M. R. WALTON: Yes.

MR. ROBERT J. MCKAY: I would say that any possible electrolytic action due to the presence of "Monel" metal would be very much less than the effect of such a current. I cannot see how the use of "Monel" metal could possibly have affected it. In an electrolytic contact between steel and "Monel" metal, the steel would be the anode and the tendency would be to deposit any copper that was present on the "Monel" metal instead of on the steel. It is probable that you had an appreciable concentration of copper in the solution on account of the use of bronzes which would probably be around 90 per cent. copper but the use of "Monel" metal would mean that this concentration would be less, since it is only about 25 per cent. copper. I am afraid I cannot be of much help in answering this question.

CALORIZING

BY ARTHUR V. FARR*

INTRODUCTION

Back in 1912 Tycho Van Aller had a friend visit him one evening at his home in Schenectady, N. Y. and invited his guest to see an experiment on which he was working. Mr. Van Aller took two copper cents and placed them both over the direct flame of a gas burner. In a few minutes both coins became red-hot. "One of those cents," Mr. Van Aller remarked, "I have treated specially and the other is the ordinary variety. We will leave them there for a few hours to see what effect heat will have on them." Towards the close of the evening, Mr. Van Aller once more took his friend to see the coins. The ordinary cent, as was to be expected, had become so badly oxidized that the image was entirely burned off. His guest picked up the treated cent after it had cooled and found to his surprise that it was just as it had been before putting it over the flame.

That was back in the days when Mr. Van Aller of the General Electric Company was trying to find some way of keeping soldering irons (really soldering coppers, because they were made of copper) clean and long wearing. He had followed the general principles of sherardizing, substituting aluminum for zinc; and the process, after certain modifications, became known as calorizing. To get convenient sized copper pieces, he used cents and it was one of the calorized cents that he used to show his friend how calorized copper resisted heat.

Besides copper, calorizing has been applied to iron, steel, nickel, etc. The resistance to the action of heat has been characteristic of all these applications and to-day the greatest volume of calorized metal is iron and steel.

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*Vice-President, Calorizing Company of Pittsburgh, Pittsburgh.

When it is considered that the loss of metals due to the action of heat runs into millions of dollars a year in this country, we recognize the importance of a process that reduces this loss. In recognition of his service to the world in inventing a means of preventing oxidation of metals at high temperatures, Mr. Van Aller was awarded the Franklin Institute medal in November, 1918. Calorizing as practised to-day has been considerably modified since Mr. Van Aller's early experiments and the following description is based upon standard methods as practised under the General Electric Company patent rights.

It should be kept in mind that, although calorized metal is more rust resistant than is either iron or steel, it serves quite a different purpose from sherardizing or other galvanizing processes. Galvanizing is one of several means of protecting metals against rust or corrosion at ordinary temperatures, whereas calorizing primarily protects metals against the action of heat. It is well known that all metals in ordinary usage oxidize rapidly at temperatures higher than dull red. By high temperatures is meant such heat conditions as are to be found in the usual commercial heating operations, such as carbonizing, annealing, baking, boiling, drying, distilling, superheating, etc.

It should be understood that calorizing is a process applied to material already made, and serves the purpose of a protective coat. It is not a cast alloy and consequently there is no difficulty in applying it to thin sections, pipes, forged parts or very small pieces. In considering a surface coating to resist heat successfully the following conditions must be met—(1) the coating should be integral with the core or metal being protected; (2) it should be able to withstand abrasion usually encountered in industrial service; (3) it should not reduce the structural strength of the metal being protected, and; (4) it should not act as a heat insulator. Let us see how these conditions are met in calorizing.

To gain a better realization of the nature of the coat that constitutes calorizing, let us see how the coat is formed. The process of calorizing as most commonly practised, consists in placing the material to be calorized in a rotary retort and heating in a reducing atmosphere, the retort being filled with a mixture containing finely divided aluminum. This treatment, conducted at a high temperature, thoroughly infuses aluminum into the exposed portion of the metal being treated, so as to form a homogeneous aluminum alloy for a certain depth. This depth ranges from a few thousandths of an inch to the permeation of the entire mass, varying with the duration of the treatment and depending upon the service requirements of the material being processed. From this it is clear that calorizing is not a coating *on* the surface, but is *in* the surface of the material. In some cases where calorized trays are used to hold steel parts being heat-treated, the trays and contents are all quenched in oil or water. Such calorized trays are giving good service without cracking. This is as good an illustration of the cohesion between base metal and calorized coat, as could be desired.

The calorized surface is hard, in fact too hard to be readily machined or threaded. It therefore presents an excellent surface to withstand abrasion or wear. It is also much harder for a given furnace heat, such as cherry red, than is iron or steel at the same temperature.

The natural question that comes to mind is, "Why does calorizing protect metals at high temperatures?" The protection is due to the oxid formed by the action of heat on the protecting metal. This oxid, known as alumina, prevents the penetration of oxidizing gases to the metal being protected. The aluminum alloys with the metal, entering into solid solution with it. For this reason, should the outer surface become injured, the protective surface renews itself by forming a new oxid coating as far as the aluminum penetrates.

With reference to the third characteristic of a good protective coat—that it should not reduce the structural strength of the material being protected—let us consider the following:

In the process of calorizing, aluminum alloys with the metal without injury to the base metal. This is due to the fact that the aluminum enters into solid solution with the metal, forming a graded penetration. On the outside is alumina, which is the protective coat; next comes aluminum, which upon exposure to heat oxidizes to alumina or penetrates into the base metal forming more alloy; next is a band of aluminum alloyed with the base metal, which is very hard and which can be converted into the protective coat, should the outer coat be destroyed or worn through; and on the inside is the base metal unchanged except being annealed from the calorizing process.

The following are physical tests on calorized steel tubing:

Test	Elastic limit lbs. per sq. in.	Ultimate strength lbs. per sq. in.	Elongation in 2 inches per cent.	Elongation in 8 inches per cent.	Reduction of area. per cent.
1	29,660	47,150*	....	....	51.6
2	28,750	45,310	30.5	23.0	42.9
3	26,290	49,020†	12.0	....	46.6
4	27,450	46,180	40.5	28.9	40.3
5	24,750	46,400	38.2	27.2	50.2
6	24,720	40,040	46.0	29.6	60.0

From this it is evident that the calorizing process gives results which compare favorably with those obtained by a soft anneal.

The reduction of tensile strength due to calorizing is dependent directly upon the cross-sectional area of the part under consideration. For instance, on a quarter-inch rod, the percentage of cross-section which is affected by calorizing is obviously greater than in a one-inch rod, so that the effect would show up more markedly on a quarter-inch rod.

CONDUCTIVITY OF HEAT

It is readily realized that the formation of a scale which grows in increasing thickness on exposure to heat, offers great resistance to the passage of heat. For instance 1/100 of an inch of iron oxid, has the same heat insulating value as one inch of scale-free iron or steel. A calorized surface, upon exposure to heat, forms a uniform and practically constant film of aluminum

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*Punch marks pulled off.
†Broke in grips.

oxid, which offers practically no increased resistance to heat, as compared with the conductivity of the metal when first introduced to the heat.

The alloy coat produced by calorizing has a lower heat conductivity than the metal itself. If the calorized part is but a small portion of the cross-section of the piece, the conductivity of the piece is not appreciably affected. After exposure to heat, however, a calorized annealing box has far greater heat-conductivity value than a steel or iron box, on account of the insulating value of the scale that forms on the surface of the steel or iron. Copper, as would be expected, loses somewhat in heat conductivity when calorized.

PROTECTION AFFORDED BY CALORIZING

As has been indicated, calorizing protects metals against burning or scaling caused by exposure to high heat. Furnace gases frequently contain sulphur dioxid and carbon monoxid which have an extremely deleterious effect on ordinary metal, whereas they have no effect on calorized metal. Although calorizing is not intended to protect against rusting or corrosion, as is sherardizing, for example, it has been found that it has protective properties other than the primary one cited. Calorized copper, brass, and nickel, for example, are excellent noncorrosive materials and are strongly resistant to brine and certain acids. Calorized iron resists the action of carbolic acid, for example, and also hot tar and pitch. The full range of the protective qualities of calorized metals has by no means as yet been ascertained.

APPLICABILITY OF CALORIZING

Iron, steel, copper, nickel, brass and, in fact, most metals can be successfully calorized. Although calorized gray cast-iron has frequently given excellent results, it is safer practice to use white metal (low-carbon, low-silicon cast-iron) owing to the fact that the surface of this remains unchanged when subjected to heat, whereas gray cast-iron "grows" upon continued exposure to heat. This growth in gray cast-iron causes the formation of surface cracks, through which the oxidizing gases penetrate and attack the inner metal. The high carbon content of gray cast-iron also tends to prevent the penetration of aluminum in the calorizing process. White cast-iron, being lower in carbon content, does not grow on exposure to heat and consequently the calorized (protective) coat is not broken by cracks, and the inner metal is fully protected.

Copper parts which are exposed to high temperature can have their life increased by calorizing. In some cases, calorized copper may be used advantageously in place of aluminum bronze. For instance, a large power station had trouble from rapid corrosion of its copper condenser tubes. These tubes, which were supposed to last a year, and which occasionally lasted six years, would sometimes fail in four to six weeks after installation. About eight years ago calorized tubes were installed and they have given excellent service.

The life of copper contacts can be increased by calorizing. For instance, a set of railroad controller contacts which were calorized showed several times the life of untreated contacts. The alloy coat produced by calorizing copper has a lower electrical conductivity than the metal itself; but, if the calorized part is but a small portion of the cross-section of the piece, the conductivity of the piece is not appreciably affected. Nickel, calorized with a light coat, resists oxidation up to 2200 degrees F. Calorized "Monel" metal, when heated to 1850 degrees F. in an oxidizing flame remains apparently unchanged.

In general, wrought, drawn, rolled, pressed, or forged metal calorizes better than cast metal, because the former are more free from casting imperfections, slag or foreign material and surface cracks.

DEPTH OF PENETRATION

The depth of penetration of aluminum as an alloy below the surface of the material is regulated according to the service conditions under which the material is to be used. If high heat only is to be considered a depth of a few thousandths of an inch of calorizing is sufficient; whereas, if severe handling or abrasive conditions are to be encountered, deeper penetration is given, even to total penetration of the metal.

TEMPERATURE LIMITS

As is well known, untreated metal begins to oxidize noticeably at 1100 degrees F. At 1500 degrees F. disintegration is extremely rapid. Generally speaking, it is safe to assume that calorized materials exposed to temperatures up to 1650 degrees F. will withstand oxidation almost indefinitely. With temperatures from 1650 to 1700 degrees F., calorized material will last from 5 to 10 times as long as when untreated, and, with temperatures from 1700 to 2000 degrees F., calorized material will show a life of from two to five times as long as similar material uncalorized. There are numerous instances where calorized material has been in continuous service from four to six months at temperatures of 1950 degrees F. without signs of disintegration, but, for general applications, 1700 degrees F. is a safe limit on which to figure.

COST OF CALORIZING

Compared with other heat resisting processes, calorizing is not expensive. This economy is due to the fact that the calorized product is made up of a relatively inexpensive metal, such as iron or steel. The continuous protective coating of aluminum does not raise the total cost of the material nearly so high as would be the case if the product were made entirely of expensive material such as nickel, chrome, cobalt, etc. The heat-resisting cast alloys of chrome, nickel, and iron in use to-day are far more expensive.

Because calorizing is ordinarily a surface-treating process, the cost is based upon the number of square feet of exposed area. Size, shape, and amount of material to be calorized in a given length of time are factors also brought into consideration in determining the cost of calorizing, just as in other heat-treating processes. It is safe to assume that the price of calorizing is materially reduced where a large and regular volume of material is involved.

USE OF CALORIZED MATERIAL

The secret of the successful use of calorized material is to preserve the aluminum oxid surface unbroken, so that no oxidizing gases may come in contact with the metal being protected. This means that cutting, machining, hammering, riveting, drilling, threading, bending, welding, or other mechanical working is best done before the calorizing process. If this rule be followed, uniformly dependable results will be obtained. What bending or working is required after calorizing, should be done when the material is heated to a bright red, at which heat the working will not affect its resistance to oxidation. Any threading required, should be done before calorizing, and the thread chased after the process, so that the part can be readily screwed into place, without marking the surface unnecessarily by wrenches. Wrench jaws should be protected by copper sheets.

It is not to be assumed from the above that calorizing is a paint or skin that can be readily scraped off; on the contrary, it will withstand all ordinary handling without destruction of the calorized surface.

Sometimes it is desired not to calorize the entire surface of an object—finished surfaces or parts that are to be welded, rolled into headers, bent, or machined, and which are not subjected to high temperature conditions. Such parts are protected during the processing so that they will not be calorized.

It should be borne in mind that material, while in the retorts being calorized, is exposed to a temperature of approximately 1600 degrees F., and the warpage due to this heat should be taken into account. Calorized material cannot be readily welded, owing to the protective oxid film on the surfaces which prevents a welding contact. The dimensions and weight of the metal treated are slightly increased by calorizing.

Observance of the above suggestions will go a long way towards obtaining highly successful results from calorizing.

VARIOUS APPLICATIONS

Iron, Steel and Metal. Retorts, carbonizing and annealing boxes, soot-blower elements, furnace parts, etc. The increased life of calorized parts has been successfully demonstrated in a wide variety of applications and conditions.

Oil and Gas. Pressure-still tubes for oil refining, valves, retorts, condenser tubes, etc. This has proved to be one of the largest fields for calorizing, owing to the high temperatures encountered and the demand for continuous service without shutting down.

Gas-Engines. Valves, piston heads for Diesel engines, preheating coils, vaporizers, hot balls for ignition.

Carbon and Coke. Retorts, capsules, pipe, and other high-temperature parts.

Glass. Calorized metal as a substitute for clay parts in connection with molten glass. Parts where calorized metal is needed because it does not throw off streaks of rust as does ordinary untreated iron; also, furnace racks, stay-bolts, pipe for conveying molten glass, etc.

Enameling. Furnace parts, such as racks and points used to support material being enameled.

Pyrometer Protection Tubes. Because pyrometers are used in such a wide variety of industries, they are deserving of special mention. The accuracy of a pyrometer depends directly upon the condition of the thermo-couple. Unless the thermo-couple is properly protected, the readings are inaccurate and the instrument worthless. Calorized pyrometer protection tubes are now sold as standard equipment by the various instrument companies and can be had by specifying them.

Thermo-Couples. Recent tests conducted on calorizing thermo-couples indicate consistently satisfactory results. These thermo-couples are used either with or without calorized protection tubes. The increased life of the couple and the assurance of dependable pyrometric readings warrant the assumption that the use of calorized thermo-couples is a growing one.

Miscellaneous. Oil-stove burners, conveying apparatus, stoker parts, roasters, rotary dryers, kiln parts, muffle rolls, seamless drawn steel pots, furnace lining, baffle plates, etc.

One of the most serious and costly phases of plant operation is the shut-down. Quite frequently this is caused by failure of a part subject to heat action. For example, a retort burns through, a tube in a still blisters badly and starts to leak, a metal support burns through and the material being processed is ruined, a thermo-couple becomes badly oxidized and breaks off, throwing the pyrometer readings out; or a host of other sources of failure arise from a similar cause. The economy of calorizing as a factor in insuring continuous plant operation will stand very close scrutiny. On this basis alone, the cost of calorizing is frequently the best invested money in a plant.

CALORIZING BY THE DIP PROCESS

There are many pieces or parts for which protection against heat action is desired, and where service conditions are of such nature that there is little, if any, abrasion or handling when the part is once in service. Stove burners, lighting-fixture parts, nozzles, grids, etc., in ordinary usage, scale and burn through and are frequently the shortest lived part of the equipment. For such parts, the dip process of calorizing has been used. This gives a light protective coat of aluminum alloy—very serviceable, but less expensive than the powder process.

DISCUSSION

Mr. M. R. Walton:* Can you calorize heavy sections of cast-iron?

Mr. A. V. Farr: I do not recommend the calorizing of gray cast-iron. Often a calorized cast-iron surface after exposure to heat is quite covered with cracks. Calorizing, of course, will not prevent cast-iron growing, as the growth is apparently due to excess carbon being thrown out of solution; but we do recommend the calorizing of white cast-iron, which remains practically constant in dimensions. Cast-steel calorizes well and that application seems to be quite successful. I would make a limitation to the cross-sectional area of the material calorized up to three quarters of an inch. On exposure to heat there is naturally a penetration of aluminum into the metal. If the continuance of the heat is sufficiently long, that deep penetration takes place, and, if the surface should be destroyed, additional aluminum oxid does not form readily enough to give proper protection; consequently we are limiting the sectional area.

Mr. J. M. Hood:† Have you ever made any experiments in calorizing annealing pots or plates such as are used in malleable-iron foundries?

Mr. A. V. Farr: We do not recommend calorizing for this purpose, if the containers are packed with an iron oxid, for the iron oxid seems to have quite an affinity for aluminum.

Mr. F. F. Espenschied:‡ Has it ever been tried for boiler tubes? The idea is to get a metal surface which will resist scale adhesion, both outside and inside. It seems to me that if you could form a surface to which the scale would not adhere, you would have done something for boiler tubes, even if the first cost of tubes is higher than for steel.

---

*Chief Engineer, Firestone Steel Products Co., Akron, O.

†Chemist, Fort Pitt Malleable Iron Co., Pittsburgh.

‡Pittsburgh District Representative, Commercial Truck Co. of Philadelphia, Pittsburgh.

MR. A. V. FARR: Of course, calorizing is used essentially as a protection against the action of heat. Boiler tubes are not exposed to sufficient heat to warrant calorizing. I have heard recently of a possible use of calorizing in boilers where low-grade fuels are used. That application has not been tried out as yet, consequently I do not know whether there would be any tendency for the calorizing to prevent the accumulation of any scale which forms on the outside. Mr. Jarrett can tell us about calorized tubes in superheaters.

MR. BROOKE L. JARRETT:* Calorizing has been used considerably in the case of superheaters where the superheaters have been independently fired, in one instance where steam at 1200 to 1300 degrees F. was developed. There, the use of calorizing was very successful. This was in Urbana, Ohio, at the plant of the Oil Refining and Development Company.

MR. W. J. MERTEN:† Have you ever had any experience in calorizing annealing pots or ovens?

MR. A. V. FARR: Yes. We have calorized annealing tubes for tool-steel bars. These have been in sizes ranging from four to 16 inches in diameter and up to 20 feet long. We have also calorized rotary tube annealing furnaces for continuously annealing rivets. These applications show a life of about three times the uncalorized life.

MR. W. J. MERTEN: How about calorizing tubes up to 25 feet in length in liquid aluminum?

MR. A. V. FARR: This can be done. We have already calorized tubes up to 23 feet long by the powder calorizing method.

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*President, Calorizing Company of Pittsburgh, Pittsburgh.

†Metallurgical Engineer, Materials & Process Engineering Department, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

The only problem for molten aluminum would be to arrange for proper furnace construction to do the work.

Mr. R. E. Butler:* We have done a good deal of work in experimenting on calorizing tubes, but we have not reached the point of putting any of the product on the market. All our work, however, was calorizing in molten metal. From our experience we would not anticipate any trouble in calorizing boiler tubes. On account of the cost, more than anything else, we thought it advisable not to carry this work any further at the present time.

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*Sales Agent, Babcock & Wilcox Co., Pittsburgh.

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THE MILES ACID PROCESS OF SEWAGE TREATMENT, - *F. W. Mohlman*

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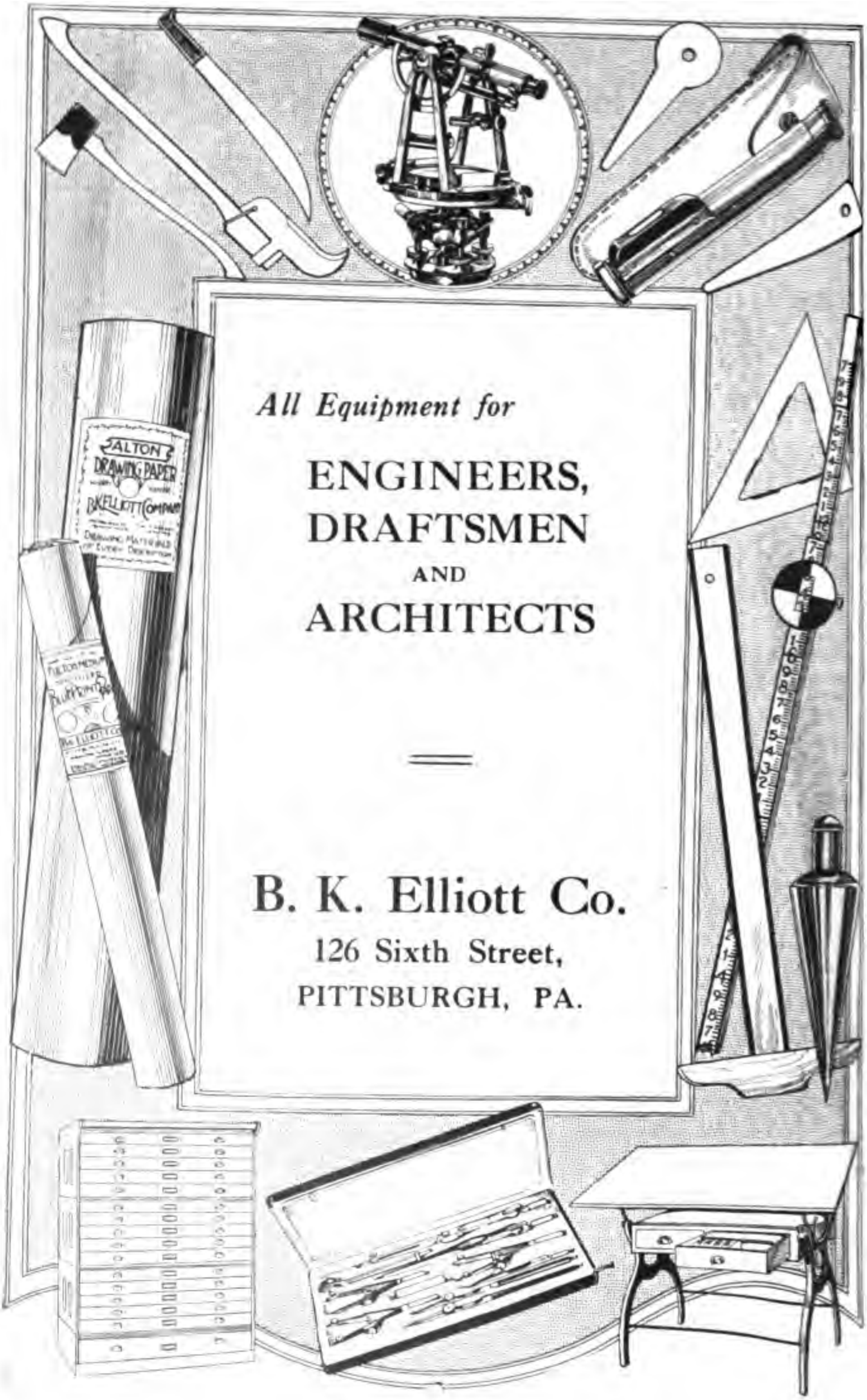

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THE MILES ACID PROCESS OF SEWAGE TREATMENT

By F. W. Mohlman*

INTRODUCTION

The addition of acid to sewage as a means of precipitating suspended solids and separating fatty acids has been practised at several cities in England for many years. In the United States a small amount of experimental work had been done prior to 1915 on the addition of sulphuric acid to sewage, notably at the Lawrence Sewage Experiment Station and in the Sanitary District of Chicago. In 1915 Mr. G. W. Miles, a consulting chemical engineer of Boston, secured a United States patent, 1134280, in which the claims were substantially as in the brief abstract below.

> "The method of purifying sewage and recovering therefrom normally non-precipitant organic matter, which consists in introducing into the sewage before decomposition of the said organic matter has materially progressed:
>
> (1) An inorganic acid as the sole effective reagent.
>
> (2) An inorganic acid under conditions which preclude the formation of insoluble soaps.
>
> (3) Sulfurous acid.
>
> (4) Sulfurdioxid, thereby producing sulfurous acid."

The real step in advance marked by this patent is contained in claims 3 and 4, in which the use of sulphur dioxid is specified. Sulphur dioxid has several advantages over sulphuric acid, which are, briefly:

1. It produces an equivalent amount of effective acid at a lower cost.
2. Sulphurous acid is a more powerful bactericide than sulphuric acid.
3. Solid brimstone is more portable and less dangerous to handle than sulphuric acid.

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*Chief Chemist, Sanitary District of Chicago, Chicago.

The use of sulphur dioxid was probably first proposed in this country by Miles's patent, but it appears that its use may have been attempted in England at a prior date, as witness a statement by Thorndike Saville,[1]* who visited the plant at Bradford, England, in 1919.

> "At Frizinghall (Bradford) where precipitation of the sludge occurs there was originally a set of sulphur burners at a gas plant. These burned the spent oxide from the gas works which contained 50 per cent. sulphur. This SO_2 gas was first admitted to the sewage through a grid of perforated pipes at the bottom of the tank. Later it was mixed by admitting it directly by means of baffle walls, the flow of SO_2 being directed in opposition to the flow of sewage. The gas remaining was passed into a tower down which the sewage trickled. It was thought that by this double process a very thorough admixture and dissolving of the gas would be obtained. The entire process was abandoned, however, because it was found that the sewage would not absorb enough SO_2 to get a proper precipitate. The use of H_2SO_4 was found less costly, owing to the ability to get a more intimate mixture and consequently less volume of acid was needed."

These notes are surprising in that they indicate that the difficulty lay in getting sufficient absorption of SO_2. The reason for this is hard to understand, inasmuch as a solubility of more than one-half per cent. of SO_2 would not be required, even if one-tenth of the sewage were pumped up through an absorption tower and mixed with the other nine-tenths before passing through settling basins. In sulphite pulp paper mills a concentration of one to three per cent. of sulphur dioxid is easily obtained, and many industrial uses of SO_2 require a concentration above one per cent. The gas works sulphid used at Bradford is not a very satisfactory source of SO_2, and probably the absorption towers were not verv efficient. If modern equipment is installed, with well designed absorption towers there should be no trouble from incomplete absorption of SO_2.

Discussion of the validity of the claims of Miles's patent is not a function of this paper. The idea was undoubtedly new in this country and no record has been found of tests prior to those made according to Miles's suggestion by E. S. Dorr in 1911.

*Numbers refer to bibliography at end of paper.

THEORY OF THE MILES PROCESS

Normal domestic sewage is usually alkaline in reaction, due mainly to the bicarbonates of calcium and magnesium. It also contains a small amount of ammonium carbonate and varying amounts of calcium and magnesium soaps. These soaps have been formed from ordinary soap, which is the sodium salt of stearic, palmitic, and oleic acids. Sodium soaps are soluble in distilled water, but, when used with water containing calcium and magnesium salts, the sodium salt is changed to calcium and magnesium soaps which are insoluble in water and in organic solvents such as gasoline, solvent naphtha, or petroleum ether.

When an acid is added to sewage, several reactions take place. According to the law of mass action the bicarbonates will be decomposed first, liberating small amounts of carbon dioxid. Then the insoluble soaps are more or less changed to free fatty acids—oleic, stearic, and palmitic—which would rise to the surface and mechanically separate from the liquid as an oily layer, if they were present in concentrated form and the sewage were heated; but which, in the cold excessively dilute sewage, remain entrained in the settling particles of suspended solids, and are carried to the bottom. As free fatty acids they are soluble in organic solvents and may be extracted from the dried sludge.

Any mineral acid will effect the changes described above, but from an economical standpoint the only acids to be considered are sulphuric and sulphurous. Sulphurous acid is most conveniently made by burning brimstone to sulphur dioxid and dissolving this in water. The equations expressing the reactions which occur when this is added to sewage are shown below. Magnesium may be substituted for calcium, as calcium and magnesium salts are affected in the same way.

$$\underset{\text{(Calcium bicarbonate)}}{Ca\,(HCO_3)_2} + 2\,SO_2 = \underset{\text{(Calcium bisulphite)}}{Ca\,(HSO_3)_2} + 2\,CO_2$$

$$\underset{\text{Insoluble in ether}}{\left.Ca\begin{bmatrix}(C_{16}H_{31}O_2)_2 \\ (C_{18}H_{35}O_2)_2 \\ (C_{18}H_{32}O_2)_2\end{bmatrix}\begin{matrix}\text{(palmitate)} \\ \text{(stearate)} + 2SO_2 + 2H_2O \\ \text{(oleate)}\end{matrix}\right\}} = \underset{\text{Soluble in ether}}{\left\{\begin{matrix}2HC_{16}H_{31}O_2 \text{ (palmitic acid)} \\ 2HC_{18}H_{35}O_2 \text{ (stearic acid)} + Ca\,(HSO_3)_2 \\ 2HC_{18}H_{32}O_2 \text{ (oleic acid)}\end{matrix}\right.}$$

In addition to the above reactions there is, of course, a marked sterilizing action, the sulphurous acid being unusually toxic to bacteria.

Another advantage that has not been emphasized is the precipitating effect of the acid on the colloids in sewage. Colloids in sewage are empirically defined as those insoluble solids which will not settle out on quiescent sedimentation. They may carry an electric charge, which tends to keep them in suspension and which prevents coagulation or precipitation. If this charge be neutralized the colloids will coagulate, until at the point where the charge is completely neutralized, called the "iso-electric point," the precipitation of colloids is at its maximum. If the charge on the colloids is negative, this "iso-electric point" is approached and passed by the addition of acids, which add positively charged hydrogen ions. The colloids in sewage are usually negatively charged and the concentration of hydrogen ions is normally about 1×10^{-8}. If acid is added until the sewage is acid to methyl orange the concentration of hydrogen ions will be approximately 1×10^{-3} to 1×10^{-4}. It is only during the past few years that the importance of hydrogen ion concentration has been recognized with regard to the coagulation of colloids, consequently the proper degree of acidity for the iso-electric point has not been worked out.

The acidified sludge produced by the Miles process is very stable and may be kept for several days in hot weather without becoming septic. An even greater advantage is its low moisture content as indicated by tests at New Haven, Conn., in which the average moisture content of all Miles acid sludge was 86.6 per cent., while that of sludge from plain sedimentation, using the same tank and the same detention period, was 90.4 per cent. It is probable that the Miles sludge could be brought down to 85 per cent. moisture by careful draining.

EXPERIMENTAL WORK ON THE MILES ACID PROCESS

The first experiments in America were made by E. S. Dorr, at Boston, in June 1911. He continued his experiments at various times until July 1914, treating a total of 26,000 gallons of sewage.

The results of these tests were confirmed by two tests made by Robert S. Weston[2] from July 7 to July 14 and from November 8 to November 11, 1915. The average results of these two sets of experiments are shown in Table I.

TABLE I. COMPARISON OF RESULTS, DORR'S AND WESTON'S EXPERIMENTS

	E. S. Dorr	R. S. Weston
Flow of sewage, Moon Island, in millions of gallons per day	92.5	103.5
Dry sludge, pounds per million gallons	1814	1909
Per cent. grease in dry sludge	22.33	22.66
Grease pounds per million gallons	436	430
SO_3 pounds per million gallons	2300	430

The average moisture content of Weston's sludge was 85.8 per cent.

Chicago. The Sanitary District of Chicago has made two tests[3] of acid treatment of packing-house sewage, the first from August 24 to November 6, 1914, and the second from May 13 to July 10, 1915. Both tests were made in a Dortmund tank with a total capacity of 1750 gallons. Sulphuric acid was used for acidification, but was applied to the strong day sewage only from 8 a. m. to 11 p. m. A total of 767,000 gallons was treated, but only 51 per cent. of the total was acidified. The sludge produced was not weighed and can only be estimated from the removal of suspended solids. The results, including this estimate, are shown in Table II.

TABLE II. RESULTS, TREATMENT OF PACKINGTOWN SEWAGE, CHICAGO

Dry sludge, pounds per million gallons (estimated)	3570
Per cent. grease in dry sludge	28.0
Grease, pounds per million gallons	1000
H_2SO_4 100 per cent., pounds per million gallons	3300
Equivalent to pounds SO_3 per million gallons	2150

Baltimore. Tests were made at Baltimore in 1915 under the direction of G. J. Requardt.[4] These tests were on a small scale, but extended over a period of 72 days, in which period 140,000 gallons were treated. Sulphuric acid was used for acidifying the sewage, which was settled in a small circular tank of 428 gallons capacity. Approximately 1600 pounds of 100-per cent. acid, or 2000 pounds 60-degree Beaumé were added per million gallons of sewage. The results were as shown in Table III.

TABLE III. RESULTS, ACID TREATMENT OF BALTIMORE SEWAGE

Dry sludge, pounds per million gallons	640
Per cent. grease in dry sludge	27.5
Grease, pounds per million gallons	176
H_2SO_4 100 per cent., pounds per million gallons	1630
Equivalent to pounds SO_2 per million gallons	1060

New Haven. The most complete tests of the Miles acid process have been made at New Haven under the direction of Prof. C.-E. A. Winslow. Four tests were made at various times between June 1917 and April 1918, the length of each test varying from 24 to 75 days. Sulphur dioxid was used for acidifying the sewage, which was settled in a tank with a capacity of 1680 gallons. Approximately 700 pounds of SO_2 were added per million gallons of sewage. The results are given in Table IV.

TABLE IV. RESULTS, ACID TREATMENT OF NEW HAVEN SEWAGE (EAST STREET)

Dry sludge, pounds per million gallons	450
Per cent. grease in dry sludge	27.3
Grease, pounds per million gallons	123
SO_2 pounds per million gallons	700

The results obtained at these four places are summarized in Table V.

TABLE V. RESULTS OF ACID TREATMENT AT BOSTON, BALTIMORE, CHICAGO, AND NEW HAVEN

City	Alkalinity parts per million	Acid used	used as SO_2 P. p. m. acid	Lbs. SO_2 per million gallons	Dry sludge lbs. per million gallons	Grease lbs. per million gallons	Tankage lbs. per million gallons	Grease lbs. per lb. SO_2	Tankage lbs. per lb. SO_2
Boston	144	SO_2	229	1919	1900	430	1470	0.225	0.77
Baltimore	153	H_2SO_4	127*	1060	640	178	462	0.168	0.43
Chicago	280	H_2SO_4	258†	2150	3570	1000	2570	0.465	1.19
New Haven	50	SO_2	84	700	450	120	330	0.170	0.47

*Equivalent to 196 parts per million, 100 per cent. H_2SO_4 used.
†Equivalent to 396 parts per million, 100 per cent. H_2SO_4 used.

Two tests of the process have been made in addition to those listed above. One test was made by the Massachusetts Department of Health, using gallon bottles, with an 18-hour period of sedimentation. As these were simply on a laboratory scale and were not followed up by tests on a larger scale, the results are not tabulated.

Another test was made at the United States Naval Training Camp[5] at Gulfport, Miss., on the sewage from a training camp. No records of flows or analyses are reported. Niter-cake was used in amounts up to 104 parts per million, and the results of a few bacterial counts of effluent compared with those obtained with the use of approximately 10 parts per million of chlorin. The director of the tests decided that chlorination was cheaper, but the absurdity of the costs given and the incompleteness of the tests render the conclusions of little moment. Niter-cake was priced at 4¾ cents per pound, which would be equivalent to 100 per cent. H_2SO_4 at about $285 a ton, whereas its normal price in 1919 was around $25 a ton. Calcium hypochlorite was listed at 6¼ cents a pound, whereas it was about four cents a pound in 1919. Hence niter-cake was over priced about 10 times and hypo about 1½ times, rendering comparison of little value.

LARGE-SCALE MUNICIPAL TEST

The tests summarized above were all experimental, and comprise the entire amount of work reported in this country. In England and Germany, however, full-size municipal plants have been operated. The best-known plant is that at Bradford, England.

Bradford. The Bradford sewage has an average grease content of 440 parts per million and has a low alkalinity. It is treated with sulphuric acid and settled in rectangular tanks. The sludge is removed from the tanks with about 80 to 85 per cent. moisture. It is pumped to the sludge-treating works, where it is treated with sulphuric acid and heated to boiling with live steam. It is filter pressed hot. the grease separating with the expressed water, from which it is drawn off for further treatment. The press cake contains from 20 to 25 per cent. water and 15 to 20 per cent. grease and is further air dried and sold as fertilizer, or burned. The acid sludge as removed from the tanks contains about 40 per cent. grease on the dry basis. Experimental work indicated that it would be difficult to separate fine particles of sludge from the solvent but according to Saville (*loc. cit.*), "A solvent process is to be installed similar to that at Huddersfield, which will extract the grease remaining in the cake." The expressed grease is boiled in lead-lined vats with sulphuric acid. After cooling, the grease is drawn off and stored. In 1904, the plant had a revenue of $29,300 but at a cost of $59,500 for sulphuric acid alone. In 1916, according to Joseph Garfield,[6] Sewage Works Engineer, the value of the grease was $387,000. Saville reports that the plant made some $500,000 in 1918.

Huddersfield. An extraction plant is in operation at Huddersfield. The sewage is settled, and the sludge removed with 90 per cent. water. Sulphuric acid is added to the sludge, which is first pressed cold until it contains about 50 per cent. water and 15 per cent. grease. The sludge cake is dried in direct-heat driers, to 15 per cent. water, after which it is extracted with benzin. The extracted sludge still contains about 5 per cent. grease. It contains 3.5 per cent. nitrogen and is sold as fertilizer.

Morley. Another grease-recovery plant in the Yorkshire district is the one at Morley.[7] This sewage is precipitated with "brown oil of vitriol" containing 80 per cent. H_2SO_4. The sludge as removed from the tanks contains 30 to 45 per cent. grease on the dry basis. It is heated and pressed hot. The grease appears in the filtrate in about four hours and continues for six hours. The grease is refined in the same way as at Bradford. The sludge cake is air dried until it contains about 28 per cent. moisture and about 20 per cent. grease, on the dry basis. Extraction with benzin removes the grease down to four per cent. The cake is sold for fertilizer. This plant was very profitable in 1919, earning about $1400 a week clear of all depreciation and interest.

These three plants have been quite successful because of the large amounts of wool-grease in the sewage, and they form a special group where unusual conditions exist. The details of their operation are given in order to indicate the practicability of drying and degreasing sewage sludge, even though the financial success of such plants may not be so assured with normal, weak American sewages.

Oldham. Among other European cities where grease extraction has been tried may be mentioned Oldham, England, where grease is distilled from acidified sludge by means of superheated steam according to a process worked out by J. Grossman[8].

At Cassel, Germany, sludge from plain sedimentation basins was filter pressed hot and extracted with benzol. The plant was abandoned on account of the excessive cost of drying and the objectionable odor of the grease obtained. According to Hopfer and Paulmann[9] the plant should have been a success if the mechanical details had been designed correctly.

At Frankfort experimental work indicated that grease recovery might be profitable. Bechhold and Voss[10] urged that the problem be studied anew and that the results at Cassel should not condemn the process.

Summarizing all foreign work on acid treatment of sewage, the consensus of opinion has been that the recovery of grease is a profitable undertaking when the sewage contains unusually large amounts of grease, but that with municipal sewages no profits could he hoped for under ordinary conditions.

The cost data based on the experimental work at Boston, Chicago, Baltimore, and New Haven have been reviewed by the writer, with the following conclusions:

Boston results indicated to Mr. Weston an apparent profit of six dollars per million gallons.

Tentative figures at Chicago indicated a substantial margin of profit over operating and fixed charges.

Baltimore results led to preliminary cost data which indicated that grease extraction would not be profitable, but that it might be able to compete in costs with other well-known processes.

New Haven results indicated no hope of profit from acid treatment, but the net cost was lower than that of Imhoff tank treatment followed by chlorination, or screening and chlorination.

The apparently favorable conclusions as to the economic success of the process in America are somewhat surprising in view of the unfavorable conclusions from European practice. The American results were all on a small scale and many difficulties in the recovery of grease and tankage may have been overlooked. These difficulties are mechanical and economic.

MECHANICAL DIFFICULTIES

1. Small-scale tests may have produced a sludge with a lower moisture content than can be obtained on a large scale.

2. Filter pressing may not be as easy as is anticipated.

3. If the sludge is not pressed but is fed into the driers directly from the tanks at 85 per cent. moisture it is possible that the sludge would ball and cake and not dry properly. Usual practice does not permit of the drying of sludge containing over 80 per cent. moisture. It has been suggested that this difficulty might be obviated by mixing dried sludge with the wet sludge, thereby reducing its moisture content as much as desirable, but the success of this procedure remains to be seen.

4. The liberation of sulphur dioxid in the drier may cause trouble.

5. The sludge may be too compact and sticky for percolation, causing channeling and making it difficult to recover the solvent by "steaming out."

6. The solvent may carry with it a large amount of colloidal organic matter in addition to the grease. These inert solids might be removed by centrifugal action but this is not assured.

7. Distillation of the grease may be almost impossible because of foaming, liberation of sulphur dioxid or excessive carbonization.

ECONOMIC DIFFICULTIES

The greatest unknown factor in the cost data so far prepared for the Miles process is the value of the grease. The cost of the acid and the value of the grease and tankage per unit for Boston, Baltimore, Chicago, and New Haven are given in Table VI. These basic cost figures led to the general conclusions summarized above.

TABLE VI. COST OF ACID AND VALUE OF GREASE AND TANKAGE

Place	Date	Cost of acid as SO_2 per short ton	Value of grease cents per pound	Value of ammonia per unit
Boston	1915	$10.00	4	$2.50
Baltimore	1915	12.30	3.5	2.80
Chicago	1915	20.00	4	3.00
New Haven	1918	16.00	5	3.00

At Boston, SO_2 was used, the cost being based upon sulphur at $22 per long ton. Sulphuric acid was used at Baltimore, its cost being $6.25 per ton of 60 degrees Beaumé (78 per cent.). Chicago acid was priced at $8 per ton of 50 degrees Beaumé (62.2 per cent.). New Haven figures were based upon sulphur dioxid from sulphur at $36 per long ton.

The value of products was considered about the same at all places, and although at New Haven grease was considered worth more than at the other three places, relatively it was considered as of the poorest quality. This fact of the poor quality of the grease was brought out by the New Haven work.

Chicago grease was valued at about half a cent less than garbage grease; Baltimore grease was considered to be worth about 80 to 85 per cent. as much as garbage grease; at Boston it was considered to be worth just as much as garbage grease; at New Haven it was considered to be worth half as much as garbage grease, which was selling at a very high price at that time (1918).

It was found at New Haven that grease extracted from sewage sludge contains an excessive amount of unsaponifiable material (waxes, mineral oil, etc.). The East Street sewage contained trade wastes and mineral oil to such an extent that from 20 to 28 per cent. of it was unsaponifiable. The sludge from the Boulevard sewage (a normal, domestic sewage) contained only 15 per cent. unsaponifiable. At Baltimore the unsaponifiable matter was 13.6 per cent. In good garbage grease the unsaponifiable matter is usually less than three per cent.

As shown by Wells[11], the crude grease would have to be distilled before being of any value. In general it may be said that grease from the Miles acid process will not be worth more than from one-half to two-thirds the value of garbage grease.

and tankage are worth even less than they were before the war. The cost of sulphur has also dropped, it is true, but not nearly as much in proportion as have grease and tankage. In Table VII and Fig. 1 are shown prices of sulphur, brown grease (similar to garbage grease), and sulphuric acid at various times from 1914 until the present time.

TABLE VII. PRICES, 1914-1921

Date	Sulphur, dollars per ton	Sulphuric acid 60 degrees Beaumé, dollars per ton	Grease cents per pound
August, 1914	22.00	20.00	6
January, 1915	22.00	20.00	6
January, 1917	35.00	200.00*	10
January, 1918	40.00	35.00	16
January, 1919	31.00	16.00	9
January, 1920	29.00	20.00	10
January, 1921	21.00	14.00	4
April, 1921	18.00	13.00	2.5

These quotations indicate that the price of grease increased from six cents per pound in August, 1914, to 16 cents in January, 1918—an increase of 267 per cent. During the same time the price of sulphur increased from $22 to $40 a ton—an increase of only 182 per cent. The New Haven cost data were therefore compiled at a time of exceptionally high prices for grease, while sulphur was relatively cheap. Since this peak value, grease has decreased to 2½ cents, a decrease of 84 per cent., while sulphur has decreased to $18 a ton, a decrease of only 55 per cent. New Haven data would consequently be out of line at the present time. If the present prices continue, the writer believes there is very little hope of being able to dispose of the grease and tankage from Miles sludge at a price sufficient to pay for sludge treatment and that it would simply remain a waste product such as other sewage sludges have been in the past. If grease values increase to at least pre-war values, it might be possible to dispose of the grease at about half the

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*Nominal.

The degreased tankage was also considered to be worth from $2.50 to $3 per unit of ammonia, the units of ammonia in the degreased tankage at each place being: Boston 4.5, Baltimore 3.0, Chicago 5.0, New Haven 3.0. If the author is correctly informed, all values of tankage were based on these ammonia contents, but no allowance was made for freight to the point of consumption. Recent studies made by I. P. Kane under the direction of Langdon Pearse, indicate that the freight item is a serious one for cities in the northern half of the United States, as by far the greatest use of organic fertilizers is in the southern states. It is possible that a small production of tankage might be absorbed locally, but, at best, freight rates would absorb the value of from one to two units of ammonia. Fictitious values for low-grade tankage are frequently given. Fertilizer manufacturers state that tankage should contain four units of ammonia in order to stand shipping.

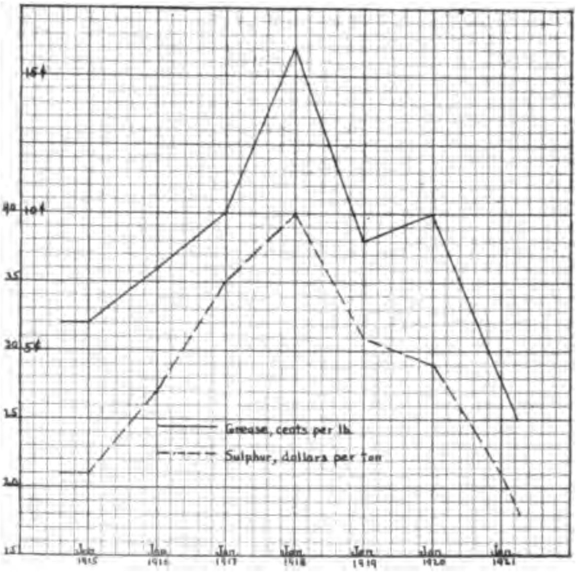

Fig. 1. Prices of Sulphur and Grease.

The low value of the grease and tankage make the Miles process almost prohibitive at times like the present when grease and tankage are worth even less than they were before the war. The cost of sulphur has also dropped, it is true, but not nearly as much in proportion as have grease and tankage. In Table VII and Fig. 1 are shown prices of sulphur, brown grease (similar to garbage grease), and sulphuric acid at various times from 1914 until the present time.

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*Nominal.

LIMITATIONS AND POSSIBILITIES OF THE MILES PROCESS

The present low value of grease indicates that it would be financially impracticable to degrease sewage sludge, as there would be no market for the grease. This does not mean, however, that the Miles process is unworthy of consideration as a practical method of treatment. Under certain conditions where clarification and disinfection are required, where the alkalinity is low and where it is essential that no nuisance be produced, the Miles acid process is a worthy competitor of Imhoff tanks followed by chlorination. When economic conditions make it unprofitable to extract the grease, the sewage may be treated with sulphur dioxid, settled in tanks, and the sludge removed and either disposed of in liquid condition or filter pressed. Its low moisture content as taken from the tanks would reduce its bulk to approximately the same as Imhoff sludge, and it might be filter pressed if necessary to bring its moisture content lower.

The effluent of the Miles process at New Haven was quite satisfactory, being considerably clearer than the Imhoff effluent. The disinfection, with an excess of 50 parts per million acidity, was more complete than the disinfection of the Imhoff effluent with 6.0 parts per million liquid chlorin. As a bactericide, sulphurous acid is highly efficient. The stable condition of the sludge, lack of septic action and odor around the plant, and absence of scum are points in favor of the Miles process.

When considered in this light there are still a few disadvantages to the Miles process. Where the alkalinity is high the cost of acid will be too great. This will bar it from most mid-west and western sewages unless other factors are in its favor. It does not produce a stable effluent, and would not prove satisfactory where very little dilution is available. Work at New Haven[12] showed that the sulphur dioxid uses up dissolved oxygen in the water in which the effluent is diluted. The SO_2 may be oxidized by preliminary aeration of the effluent before it is discharged, and it is probable that the sulphuric acid produced would be quickly neutralized by the bicarbonates present in practically all natural waters.

If the sewage contains iron, acid treatment might be inadvisable, as iron would be kept in solution and possibly even some insoluble iron might be dissolved, which upon neutralization with the bicarbonates in a stream would precipitate and cause unsightly discoloration of the stream. Recent experiments at New Britain, Conn., indicate that such effects may occur.

If the value of grease increases to a point where it could be sold for enough to pay for the cost of extraction, complete equipment for the Miles process would have to be installed. This equipment comprises:

a. Sulphur burners.
b. Absorption towers.
c. Tanks.
d. Presses.
e. Driers.
f. Extractors.

If the recovery of grease and tankage were not attempted, only sulphur burners, absorption towers and tanks would be required.

Sulphur Burners. The sulphur dioxid could probably be produced most conveniently by burning brimstone rather than pyrite. Before the war SO_2 could be produced more cheaply from pyrite than from brimstone, but since freight rates have advanced, brimstone has been used by most producers of SO_2. Pyrite contains not over 53 per cent. total sulphur, brimstone 99 per cent. Pyrite leaves a cinder consisting of iron oxid containing about four per cent. sulphur, which is not suitable for blast-furnace use unless treated further to reduce the sulphur content below one per cent. The large piles of cinder which would accumulate would be most undesirable. The production of SO_2 from brimstone is comparatively simple, the most efficient type of burner being a rotating kiln similar to a cement kiln or direct-heat drier. These burners are usually three feet in diameter and eight feet long, with a capacity of 250 pounds of sulphur per hour. They are easily regulated and produce a uniform content of SO_2 in the exhaust air.

For smaller capacities the pan type of burner might be more suitable. This consists of a simple shallow fire-pot into which the sulphur is fed from a hearth in front. The capacity of this type may be as low as 100 pounds per 24 hours.

Absorption Towers. The absorption of SO_2 in the sewage should be carried out in a tower filled with some kind of porous material such as pumice, quartz or coke, or preferably filled with a uniform pottery grid according to the most modern absorption methods. The proportionate volume of sewage that would have to be pumped to the top of this tower would vary with local conditions, but need never be over five per cent. of the total flow. It would be safest to pass this portion through a fine screen before pumping, to prevent stoppage of the open spaces in the tower packing. The general practice of paper-mill production and absorption of SO_2 might safely be followed in the absorption apparatus of a Miles plant. Cheaply constructed coke towers would probably lead to trouble from clogging and poor absorption. As only three to five per cent. of the sewage need be pumped to the top of the tower, the power cost would be quite low.

Tanks. The acidified portion of the raw sewage could be mixed with the remainder in any sort of baffled mixing chamber as the diffusion of the acid is rapid. From this chamber the acid sewage flows to the settling tanks. Any form of rectangular or circular tank should be satisfactory for sedimentation but special precautions must be taken to prevent decomposition of the concrete, by covering it with a thick coating of acid-proof paint or asphalt. As the sludge is comparatively inert no double-deck arrangement need be made to prevent gas evolution from disturbing the settling solids. Sludge should not be allowed to accumulate for too long a period, however, as the acid eventually is neutralized and the sludge may become septic, possibly in two or three weeks. For this reason a uniform, systematic removal of sludge is advisable. In the writer's opinion Dorr thickeners seem to be exactly suited to the needs of the Miles process. They require a negligible amount of power, produce a homogeneous, dense sludge which may be removed whenever desired. The unsanitary, nauseating process of removal of sludge by means of squeegees would be obviated. Collection and removal of sludge from sumps is not considered feasible in shallow (10-foot) tanks. There are no results to show what Dorr tanks might do in the thickening of Miles acid sludge, but from the writer's experience with acid sludge at New Haven and a 20-foot Dorr tank working on tannery wastes at Chicago, he feels confident that the moisture content of New Haven sludge could be reduced to 85 per cent. in Dorr thickeners. Dorr thickeners, although requiring special mechanism, should be no more expensive than Imhoff tanks, due to the simplicity and shallowness of the tank itself. The power consumption is quite low, a 60-foot thickener being driven easily by a 10-horse-power motor.

Presses. The treatment of the sludge is an integral part of the Miles process, but, unfortunately, no experimental work on a sufficiently large scale has been done on the sludge. The plans for drying and degreasing the sludge are based upon very little data, and need hardly be more than mentioned here. If the sludge can be reduced to 85 per cent. moisture as taken from the tanks, it would probably be cheaper to dry it directly, without filter-pressing. If the moisture content cannot be reduced below 90 per cent. it will be necessary to press. It is probable that no insurmountable difficulties would be encountered in filter pressing Miles sludge, as it dries very quickly on sand beds. If it is necessary to press, there is the possibility that it might be advisable first to press cold to remove as much water as possible, then to steam the presses and remove as much grease as possible in this way, following the practice at Morley, England. It is probable that even after hot pressing the cake would contain 10 to 15 per cent. of grease (on the dry basis) so in either case driers would be needed.

Driers. Direct-heat driers must be used for mechanical drying, as steam drying is too expensive. Care must be taken to use a drier with a long fire-box and an indirect method of introducing the hot air into the rotating cylinder in order to prevent the sludge from catching fire. Several varieties of direct-indirect driers, now operating successfully on inflammable food products, should be satisfactory for sludge drying. There might be trouble from balling or caking, but a way out of this could no doubt be found by large-scale tests.

Extractors. After drying to 10 to 20 per cent. moisture, the sludge is ready for extraction. Horizontal, revolving cylinders are used as extractors. The cylinder has a filtering medium at one end and is fitted with both closed and perforated steam coils. The sludge is flooded with solvent, which is simply a low-boiling gasoline. The cylinder is closed and revolved for a short time, at first cold, later heated by the closed coil. The solvent plus extracted grease is then filtered away and more solvent added. After extraction is complete as much solvent as possible is vaporized by the closed steam lines, then live steam is admitted and the charge is "steamed out." The condensed steam is separated from the solvent. The solvent is distilled away from the grease in a specially designed still.

"Steaming out" adds moisture to the tankage, which must be removed before it can be sold as a fertilizer. As removed from the extractor the degreased tankage contains about 30 per cent. moisture, which must be reduced to 10 per cent. or less by drying.

The quality of the grease may be improved and its value increased by distillation. It is probable that this would have to be done before the grease could be used for soap making or for leather grease, but it would be preferable to sell the crude grease to a distiller of fatty acids rather than to attempt to distill it at the sewage works.

Conclusion. In conclusion, the writer feels that the possibilities of the Miles process should not be dismissed without a fair trial. Where clarification and disinfection are required a brief investigation of the alkalinity and composition of the sewage will indicate whether or not the Miles process is worth consideration. Fairly small-scale tests will show the amount of SO_2 required, the moisture content of the sludge, the quality of the effluent and the bacterial removal. If it appears that extraction of grease may be profitable, larger-scale tests are necessary to demonstrate the value of recoveries. If grease is so low in price that extraction is not advisable, the acid process may be balanced against

Imhoff tanks and chlorination, without recovery of grease and tankage. Where trade wastes interfere with normal Imhoff tank digestion, as occurred at New Haven, acid treatment may be practically the only alternative. It may be depended on to give a better effluent than that produced by an Imhoff tank or a plain sedimentation tank.

The general attractiveness of the acid process, its lack of scum and odor, and the efficient disinfection and clarification effected, all appealed to the writer during the experimental work at New Haven; and, although it appears that its field is limited, it possesses possibilities that should not be ignored. Further large-scale investigations of some of the mechanical processes involved would be of value in furthering the science of sewage treatment and waste recovery.

The writer wishes to acknowledge his indebtedness to Mr. Albert W. Dilling, Chief Engineer of the Sanitary District of Chicago, for the use of certain data contained herein.

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DISCUSSION

MR. W. L. STEVENSON:* The writer has had no actual experience with the Miles acid process of sewage treatment which is so completely set forth in Mr. Mohlman's paper but desires to call attention to some pertinent ideas developed in this process which may prove useful.

When our forefathers came to this country they found a land rich in all natural resources—forests, game, mineral wealth and streams of pristine purity. It seemed actually inexhaustible and hence no thought was given to conservation. Through reckless waste we have destroyed our forests, relegated game to preserves and museums, and turned many of our streams into open sewers. The tide is turning, and through legislation the waste of natural resources is being curbed. It is futile to dream of restoring our streams to a condition of purity, but it is feasible to restore the polluted streams and maintain the unpolluted ones in a condition of cleanliness, as fit sources for public water-supplies and other public and private uses. The natural storm-water run-off from towns must of necessity flow to the streams, but the filth of towns, and liquid wastes of industry can be so treated before discharge as to maintain decently clean watercourses. Here, too, we should apply the principle of conservation.

Natural bodies of water contain the forces needed for the ultimate purification of organic matters; namely, bacteria and dissolved oxygen. These natural forces should be utilized to the fullest extent compatible with protection of the public health, and assurance of prevention of nuisance; but we cannot overtax these free gifts of nature, and so it becomes necessary to expend public and private funds for the artificial treatment of sewage and trade wastes to effect that part of the ultimate purification of these wastes which is beyond the power of the natural forces. The cost of this artificial treatment should, in justice, be equitably distributed among the several users of the streams; for instance, it is eminently unfair for one municipality to deplete the natural forces of a stream by the discharge of untreated sewage so that the next town down the stream is required to treat its wastes to a high degree to avoid creating nuisance conditions, or so that the stream cannot with safety be used as a source of water-supply.

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*Assistant Chief Engineer, Engineering Division, Department of Health, Harrisburg, Pa.

If we accept these principles, it naturally leads to the requirement of progressive treatment of sewage and industrial waste, so as to be able to lighten the load upon the stream as the population upon the watershed increases and sewer systems are extended. Still having in mind conservation, it is highly desirable that the cost of such treatment be reduced by recovery of by-products wherever possible. This is particularly applicable in the treatment of industrial wastes.

The Miles acid process is an attempt to this end through the recovery of grease, and hence is worthy of careful study; but it should be borne in mind that, if the grease recovered has a market value below the cost of recovery, it is futile.

The presence of grease in sewage is one of the serious causes of trouble in the operation of sewage-treatment works. It is resistant to oxidation; its presence in sludge retards inoffensive decomposition; it causes clogging in intermittent sand filters, contact beds and trickling filters; and causes "sleek" in the receiving body of water; therefore, any means which will reduce the quantity of grease in sewage is to be encouraged.

The optimum place of removal is at or near the point of origin, before the grease has gone into a colloidal or dissolved state. This naturally leads to the policy of installing grease traps on drain pipes from places where much grease is discharged, such as from institution kitchens, abattoirs, and industries wasting oil or grease. Such grease traps should be of sufficient size so that opportunity will be afforded for the temperature of the waste to be lowered to a point such that the grease will congeal and float to the surface. The greasy scum must also be removed at frequent intervals to secure efficiency in the grease trap.

Among the factors in retarding advance in knowledge of sewage treatment are conservatism and the present cost.

A new process like the Miles acid treatment should be given a trial on a small scale so as to develop its virtue or demonstrate its fallacy, for if it be demonstrated that the cost of treatment can be reduced through recovery of a by-product, we have not only conserved funds but have added to our supply of raw materials through the grease recovered.

MR. G. F. MAGLOTT:* I desire, if I may, to compliment the speaker on the conservatism with which he has treated the subject.

Some years ago I had the good fortune to be associated with the Sanitary District of Chicago on the investigations upon the Packingtown wastes.

As I recall it, our tentative conclusions were then that the recovery of the grease would not be economical except as a skimming enterprise. We had in mind at that time—1912, before the Miles acid treatment was heard of—that treatment by acid might recover more of the grease than we were able to obtain by skimming, but the economics of the proposition were such that we doubted its justification as a commercial process. Since then the field has been extended a great deal.

During the operation of the experimental degreasing plant at Hudson, Mass., Mr. Weston's staff told me something of the results which they had obtained. The drainage contained a large quantity of wool scouring wastes, and the object of the experiments was to collect data on recovery of grease therefrom. The data were derived during the time of the war. The grease was of such character that it was worth, then, about 20 cents a pound, and their conclusions were that in such abnormal times the degreasing process was a good scheme and showed good economy, but that, with pre-war prices it was very doubtful if the process would be economical.

I understood the speaker to say that the Miles acid process is not one to be suggested for the treatment of ordinary sewage, except under unusual conditions. I should like to be set right on that.

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*Division Engineer, Morris Knowles, Inc., Pittsburgh.

MR. F. W. MOHLMAN: That is quite true.

MR. G. F. MAGLOTT: There is another angle to the question in this vicinity. We suffer a great deal from acid streams, the acid arising from coal-mine drainage, which becomes oxidized and appears either as combined or free sulphuric acid, the free acid being mostly sulphuric, with some sulphurous acid. The result is that it is becoming more and more difficult every year to obtain a water-supply, in the western part of Pennsylvania, which is fit for either domestic or industrial consumption. The situation is particularly acute in the case of industrial water-supplies, because of the large quantity of sulphates contained in the raw water. Sulphates, whether combined or free, are, as you know, the trouble makers *par excellence* in a boiler water.

I have not computed the effect which the Miles acid process might be expected to have on the acidity of the streams here; perhaps it would not be material on such a stream as the Monongahela, or the Youghiogheny, or even upon a stream as small as Turtle Creek.

In your opinion would the use of the Miles acid process have a deleterious effect either where the streams are acid in this vicinity or in New England where the streams are low in alkalinity, due to the discharge of an acid sewage or one containing large quantities of sulphates?

It seems to me that the sewage effluent from a city like Lawrence, Mass., or Pittsburgh, if acid to the extent of 50 parts per million, might have a decided effect on the chemical quality of the rivers draining these cities.

At any rate the extensive use of the Miles acid process certainly would not improve the quality of the stream waters in this vicinity where our every effort must be to reduce, not to increase, the pollution of water supplies by sulphates.

MR. J. P. LEAF:[*] I have surely enjoyed this paper. I agree very heartily with the speaker that we must take care of our streams better than we do—the Beaver River, the Ohio River and the Youghiougheny River in this vicinity. The bane of these rivers is sulphuric acid. The government dam at Davis Island is practically ruined from the sulphur and sulphuric acid in the water. I do not know that that will be a bad thing in the end because they will build permanent dams which will give Pittsburgh a winter harbor and probably give us power. But in a great many places in the United States we are almost at what you might call the limit of the natural use of the rivers. We pollute them with manufacturing wastes and domestic sewage, until it has almost reached the point where we must go some place where there is good water to use for domestic purposes. I believe that conservation of water is the largest proposition we have. We must have more water and we must have a great deal better water. It is a question whether our manufacturers are entitled to use the rivers as sewers in taking off manufacturing wastes or whether we should compel the manufacturers to take care of their wastes so they do not pollute the waters. I think there is a good deal done in Pennsylvania along that line. Youngstown, Ohio, has already spent a good many hundreds of thousands of dollars—yes, millions—in trying to get enough water of any kind to use. Sharon, Greenville, and New Castle, and I have no doubt the cities along the Monongahela, are up against the same thing. They are practically up to what you might call the limit of the natural supply of water. We must keep these floods back and use them for the purification of the streams at low water. Last year was a wonderful year, not quite as much rainfall as normal but distributed over the year nicely. I have known several towns where factories had to shut down because they did not have enough of any kind of water, and with what they did use there was quite a lot of trouble with the boilers.

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[*] City Engineer, Beaver Falls, Pa.

As to the matter of sewage treatment, I have the fortune or misforune to use the only Imhoff tank used in this district. When you try to treat an effluent from city sewage, where they put everything in the sewage from offal from manufacturing plants and pickling works to grease from slaughter-houses, the Imhoff tank while it is very nice as a theoretical proposition certainly needs quite a lot of additions to it. We have treated the effluent with chlorin, 25 pounds to the million gallons, and got results but it is an expensive proposition. Down in Ohio they say they treat the water and the cows like to drink the effluent. Our system produces a million gallons of effluent a day and I do not think the drinking proposition would be very inviting. Our effluent is discharged into a pool where the neighbors get drinking water and we try to watch it carefully, and we get a good deal better effluent from a bacteriological standpoint than they have in the river. However, the river is pretty bad to start with. The Ohio River and tributaries are not very inviting as a water-supply, in my estimation. We are up against the proposition that it is the only thing in the region that we can get that will produce enough water for our use. I think we will find in the near future that in western Pennsylvania where the population is so dense, we will have to be very careful of our water-supply.

MR. H. R. THAYER:* Some of the discussion this evening was taken up on the situation that is facing many crowded municipalities in attempting to obtain a plentiful supply of pure water. For a number of years it has been my opinion that we will eventually reach a solution using two separate systems of water-supply derived from two sources—for drinking and cooking, and perhaps for boilers, coming from mountains or such a restricted watershed that it can be protected and no pollution will be possible; and another obtained from the rivers, kept simply clean enough not to offend the sight, so that it may be employed for cleaning and laundry work.

It seems to me that in a district like Pittsburgh, New York or Boston, we will be driven eventually to some such solution of the problem. In these large metropolitan districts they are considering sources many hundred miles away and then they look forward to the time when the present methods will not supply the water that is required. The solution that will have to be reached will be to use their polluted rivers, probably with some cheap but fairly efficient filtration, and utilize the pure supply for drinking and cooking only.

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*Markhart-Thayer Engineering Co., Pittsburgh.

Taking up the interesting paper we have heard this evening, it is a remarkably good one, which we have all enjoyed. It has covered the ground pretty thoroughly but there are a few minor questions I would like to ask. Has the centrifugal process of extracting the water from the sludge ever been attempted, and if so, what have the results been?

How would the effluent from the Miles acid process compare with other methods, if used for drinking water? Here in Pittsburgh some of us have been drinking water that is full of acid —the Miles acid process, or a substitute for it.

I would also like to ask how it compares with filtration, or whether the author still considers filtration as much the better process for the usual situation.

Mr. F. W. Mohlman: In reply to the first question about centrifugal extraction; we had a small centrifugal machine in New Haven and when we tried to de-water the sludge we were quite surprised to find that the centrifugal caused quite a segregation of the grease. Our cake contained only about a third of the grease that was originally present in the wet sludge. The grease had gone off with the liquid effluent. As the Miles process was originally intended, the centrifuge would defeat the object: that is, to recover the grease in the sludge.

Mr. H. R. Thayer: It would pollute the water, would it not?

Mr. F. W. Mohlman: Yes, the effluent would be quite heavily polluted—much more so than the sewage itself.

As to the last question, concerning the degree of treatment afforded by the Miles process, the result lies somewhere between sedimentation and complete treatment, and of course it will not furnish nearly as good an effluent as would be produced by sprinkling filters or by activated sludge.

Mr. H. R. Thayer: Does sulphuric acid act in quantities to make it objectionable?

MR. F. W. MOHLMAN: As I said before, it will depend upon the stream flow and the alkalinity of the water into which the effluent is discharged. Under most conditions, if there is a dilution of say 1 to 25, the acidity will be neutralized by the normal alkalinity of the stream; but that is something that can not be answered generally—it is a specific problem for each locality.

MR. A. E. BLAKE:* I should think the more intense the centrifugal treatment you could give, the more grease you would fail to separate from the water, because most of the grease is lighter than water and you would only get the heavier portion, or such as might be entrained by other heavier matter.

In certain parts of the country, they would be very glad to find new uses for liquid SO_2, and if sulphur can be shipped from Louisiana to Illinois, I think the rates of shipment would not be any greater than that for SO_2 from the West. Its use would greatly reduce the installation and operating costs of the process.

MR. F. W. MOHLMAN: It would have to be very cheap—less than one cent a pound.

MR. A. E. BLAKE: I think you can get it for less than one cent a pound.

MR. LOUIS P. BLUM, *Chairman*:† The paper of the evening is a notable contribution to the literature of the subject, and it is the more notable because the author has dispassionately given us the limitations of the system. Pioneering papers of this character frequently form the basis of future engineering progress. I would like to ask the speaker as to his opinion of the best method of disposal of sludge when no attempt is made to remove the grease and tankage.

MR. F. W. MOHLMAN: The same way in which Imhoff sludge is disposed of at the present time—simply as a waste product.

*Pittsburgh Representative, U. G. I. Contracting Co., Pittsburgh.
†Blum, Weldin & Co., Pittsburgh.

Mr. Louis P. Blum: Has it any value as a fertilizer?

Mr. F. W. Mohlman: Not with all that grease. It would be just as much a waste product as Imhoff sludge, but the effluent might very likely be better than the Imhoff effluent. The disinfection would probably be greater than you could get economically with chlorin, and the effluent would be clearer, but you would still have the trouble of disposing of the sludge, just as in the case of Imhoff sludge.

Mr. J. P. Leaf: Does any one know any way of utilizing the Imhoff sludge?

Mr. Louis P. Blum: What do you do with it?

Mr. J. P. Leaf: We have some farmers using it but we have never had any reports as to whether or not it is good. We have quite a pile and would be glad to give it to any one who would take it away. There is only a small amount of fertilizer in the sludge, but if we could get any one to use it on a heavy soil like a shale soil in connection with lime it might be a good thing.

Mr. Louis P. Blum: The difficulty of disposing of the sludge seems to be common to all methods of sewage treatment.

Mr. G. F. Maglott: I understand that the Miles acid process gives a dense and sticky sludge ordinarily containing an unusually low percentage of water, and I thought I heard the speaker say that it would dry on the sand about as easily as Imhoff tank sludge. I would surmise that a sludge apparently similar to activated sludge would be dried only with difficulty. What accounts for this ease in drying Miles acid sludge?

Mr. F. W. Mohlman: I am just basing that statement on the results obtained in New Haven where it did dry very satisfactorily. There may be something in the effect of the acid on colloids which may permit the water to be drained away more easily.

Mr. Louis P. Blum: How about this Imhoff sludge?

Mr. J. P. Leaf: Every time we pump sludge out the neighbors that see it smell it with their eyes. I tried to get them to believe that it smelled like a brewery and they seemed to think that the odor is not bad. In the Beaver Valley there are manufacturers that use a great deal of sulphuric acid that is supposed not to get in the sewers, but it does, and the sulphur turns into H_2S and that is bad; but, theoretically, the Imhoff tank is a pretty good thing.

When you begin to treat city sewage there are a good many problems which are pretty hard to solve. We found in the army when we were treating the cantonment sewage that in a very short time the matter of taking care of the sludge became an awful problem. Some of the cantonments had sand pits and they would fill these up with sludge and it does not dry very fast in the winter. If you can get your sludge cured properly it dries out pretty easily, but if you have any grease or undigested sediment it seems to hold water like glue. I have tried several disinfectants on the sludge—chlorid of lime, crude oil, and chlorin. I have also tried sulphate of iron. That is a pretty good thing because after the sludge goes on to the bed, while the water is draining away, it keeps it from any further putrefaction.

Mr. A. E. Blake: There are some very interesting methods of breaking oil-water emulsions, etc. In southern California they drilled a few years ago and got an emulsion of salt water and petroleum that was very hard to break, and Dr. Cottrell evolved a remarkably simple and efficient process of breaking it up. From that came the Cottrell process for purifying gases.

Mr. A. Pinkerton:* I was just wondering what the difference is between this Miles process and the process I have seen in successful operation at Glasgow, Scotland. Do you know anything about that process?

Mr. F. W. Mohlman: No.

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CONTACT CATALYSIS

By WILDER D. BANCROFT*

A catalytic agent may be defined as a substance which accelerates a reaction without being much changed thereby. When the catalytic agent is present as a separate phase and not in solution, we speak of contact catalysis. There seem to be two distinct types of contact catalysis—one in which definite intermediate chemical compounds are formed, and the other in which we have adsorption with activation. When hydrogen peroxid is decomposed catalytically at a mercury surface, we know that an intermediate compound is formed because we can see it and because it can be removed and analyzed. A film of mercury peroxid forms over the surface of the mercury and then decomposes into mercury and oxygen, after which the cycle recurs again and again. When alcohol is oxidized to acetaldehyde in the presence of osmium tetroxid, we know that an intermediate compound is formed because alcohol reacts with osmium tetroxid in the absence of air to form acetaldehyde and a lower oxid of osmium, which latter is easily oxidized back to the tetroxid.

During the war a carbon monoxid adsorbent was developed by members of the staff of the Johns Hopkins University and the University of California, for which reason it was given the barbarous name of "hopcalite". It consisted of a mixture of oxids such as copper, silver, manganese, etc., prepared in a special way, and it caused carbon monoxid and air to react to form carbon dioxid. It seems practically certain that the mixed oxids oscillate between two stages of oxidation though there may be some question as to what the two stages are. This adsorbent was developed primarily for use by the Navy; but it is proving a great success in gas masks to be worn by men going into mines where there has been an accident. Of course, it must be remembered that the formation of an intermediate compound does not account for

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the increased reaction velocity; but we have to know what happens before we can hope to explain why it happens.

All solids tend to condense upon their surfaces any gases or vapors with which they are in contact. This increased concentration in or at the surface is called adsorption and the amount varies with the temperature and pressure and nature of the gas, and with the nature and physical states of the solid. A solid adsorbs a liquid when it is wetted by the latter and it may also adsorb dissolved substances, thereby removing them more or less completely from the solution. The decolorization of sugar by charcoal is a familiar case of this and the process of dyeing textiles is entirely a case of adsorption. In general, adsorption does not involve the formation of definite chemical compounds. The increased concentration at the surface plays but a negligible part in the increased reaction velocity because platinum black will cause oxy-hydrogen gas to combine at ordinary temperatures, and yet, during the war, it was found that oxy-hydrogen gas could be compressed to two thousand atmospheres and still not react. There is a specific action of the platinum black. For the present, all we can say is that adsorption is often accompanied by activation and we are now trying to find out just what the activation consists of in each special case. There may be a breaking of certain bonds or there may be an opening of what we call contravalences, or something else may happen. We are not very far along as yet in the theory of contact catalysis; but we have at least formulated the problem definitely, which had not been done before, and the next few years will undoubtedly see a rapid development of the theory.

Phosgene, $COCl_2$, was made during the war by the interaction of carbon monoxid and chlorin in presence of a special charcoal as catalytic agent. By passing alcohol over heated alumina or kaolin, the alcohol was decomposed into ethylene and water according to the equation $C_2H_5OH = C_2H_4 + H_2O$. The ethylene was one of the materials used in making "mustard gas." If alcohol is passed over heated nickel, it is decomposed practically quantitatively into acetaldehyde and hydrogen, or $C_2H_5OH = CH_3CHO + H_2$.

These last two illustrations show the specific action of different catalytic agents and indicate the possibility of making reactions go in different ways by the use of suitable catalytic agents.

One striking characteristic of contact catalytic agents is the way in which their effectiveness is destroyed by the presence of small amounts of certain impurities, the ease with which they are poisoned, as we call it. A few years ago, this poisoning was considered a practically insoluble mystery; but, to-day, the theory of it seems quite simple. Since the reaction takes place in or at the surface of the catalytic agent, anything which cuts down the rate at which the reacting substances reach the surface of the catalytic agent will decrease the reaction velocity. If the reaction products are prevented from reaching the surface of the catalytic agent, all catalytic activity will cease. It is easy to see that a solid film over the surface on the catalytic agent may destroy its activity, just as we do not get the bitter taste of quinine if we have it in a sugar-coated pill or in a gelatin capsule. A film of a strongly adsorbed gas may also cut the absorption of the reacting substances down practically to zero and thereby cause a very complete poisoning.

We know that traces of grease from the air or from the stopcocks of the apparatus may decrease the adsorption of hydrogen by palladium from about nine hundred volumes to practically nothing. With platinum, traces of grease cut down the adsorption of hydrogen from over one hundred volumes to a negligible amount, and, nearly ninety years ago, Faraday showed that platinum catalyzes oxy-hydrogen gas only when perfectly clean. Nearly eighty years ago, Schönbein showed that hydrogen sulphid decreased the catalytic action of platinum on mixtures of air with hydrogen or ether. He considered that a film of sulphur was probably formed; but he did not test this explanation. Quite recently Maxted, in England, has shown that hydrogen sulphid is decomposed by platinum black with evolution of hydrogen and that the platinum thereby loses its power of adsorbing hydrogen. For over twenty years it has been known that carbon monoxid poisons platinum so far as the reaction between hydrogen and ethylene is concerned, and, within a year, Taylor and Burns, of Princeton, have shown that carbon monoxid is adsorbed so strongly by platinum that the adsorption of hydrogen and ethylene becomes negligible. If the reaction products are not removed rapidly from the catalytic agent, their presence may retard the approach of the reacting substances and thereby cut down the reaction velocity. This has been observed in the contact sulphuric acid process where the presence of the sulphur trioxid formed may slow up the reaction.

When working with a suspension of finely divided palladium in a liquid, there is always danger that the particles may agglomerate, thereby decreasing the surface. The suspension can be stabilized by adding what we call a protecting colloid; but the film thus formed round the particles of palladium acts as a partial poison and we therefore have to strike a balance between a very effective but instable catalytic agent and a very stable but more ineffective one.

Many of the reactions which are accelerated by contact catalytic agents are exothermal ones; they take place with evolution of heat. In the contact sulphuric acid process, there is an evolution of about 22,600 calories per molecular weight of sulphur trioxid formed, or nearly three hundred calories per gram. This evolution of heat takes place in an extremely localized region—at the surface of the catalytic agent—and the problem of maintaining the temperature constant is therefore a very serious one. This is essentially an engineering problem and its importance appears when one sees the number of patents dealing with this point for the contact sulphuric acid process.

CONTACT SULPHURIC ACID PROCESS

It may be interesting now to say a few words about several of the important technical applications of contact catalysis. The first is, of course, that of contact sulphuric acid. In presence of platinum black, sulphur dioxid and oxygen react to form sulphur trioxid, the anhydrid of sulphuric acid, or $2\ SO_2 + O_2 = 2\ SO_3$. Platinized asbestos is the contact material in one form of the process, while the Schroeder-Grillo contact material consists of hydrated magnesium sulphate soaked in a solution of a platinum salt and then heated in presence of sulphur dioxid as a reducing agent. A thin layer of platinum is thus precipitated on the surface of the porous, dehydrated salt, 0.2 to 0.3 per cent. of platinum giving an excellent catalytic agent.

Although the use of platinized asbestos was patented in 1846, the contact process for sulphuric acid was not put on a sound commercial basis until this century. When laboratory experiments with apparently purified burner gases were repeated on a commercial scale, the contact material soon became inert, because enormous volumes of gas are handled and the presence of infinitesimal amounts of such poisons as arsenic oxid leads to cumulative deposits on the catalytic agent. By cooling the burner gases slowly and bringing them into intimate contact with sulphuric acid, it was found possible to obtain a gas mixture which passed all ordinary optical and chemical tests and which appeared to be pure. When tested on the large scale, it was still found to contain arsenic. The gases had been cooled in long iron tubes and had reacted with these sufficiently to give traces of arsine. This difficulty was eliminated by not letting the gases come in contact with the iron. When the roaster furnaces were run to maximum capacity, however, a slight cloud was formed, which could not be got rid of and which proved to consist of unburned sulphur. This in itself would have done no harm, had not the particles of sulphur contained some arsenic. It therefore proved necessary to admit enough air so as to be sure that the sulphur was burned completely. The American chemists were able to filter out all the solid poisons, though the Germans claimed that this could not be done.

Under equilibrium conditions sulphur trioxid begins to be dissociated perceptibly at about 400 degrees and is practically completely dissociated at 1000 degrees. At first sight it would therefore seem that the process should be run at or below 400 degrees; but the time factor cannot be ignored. Under commercial conditions there is practically no reaction below 400 degrees and it has proved more profitable technically to work at about 450 degrees with perhaps 95 per cent. conversion in a reasonable time than at 400 degrees with 100 per cent. conversion in an unreasonable time. The increased reaction velocity at the higher temperature compensates for the decreased chemical efficiency.

Ferric oxid can be used as a catalytic agent; but the reaction velocity is less for any given temperature than with platinum, and consequently it is necessary to work at a higher temperature with a correspondingly lower chemical efficiency—perhaps 60 per cent. In order to cut down the cost of platinum, it has been suggested that ferric oxid and platinum be run in series.

Ferric oxid is much less susceptible to arsenic poisoning than is platinum, presumably because of the higher temperature at which it acts. Since arsenic oxid is itself a catalytic agent when free from iron, there must be temperatures at which it will have little or no deleterious action. If one could make a ferric oxid catalyst which would work at as low a temperature as platinum, it would probably be about as sensitive to arsenic poisoning as is platinum. It is entirely a question of the way in which the arsenic precipitates on the surface of the catalytic agent. That this is the case appears from an experience which Reese once had. When working with platinum on a magnesium sulphate base it is possible to regenerate the contact material by heating it with hydrochloric acid, after it has been poisoned with arsenic. The assumption was that the arsenic was volatilized as the trichlorid; but analysis showed that there might be two to three per cent. of arsenic in the regenerated catalyst without its having any apparent effect, although half that amount of arsenic is quite sufficient to destroy the catalytic action completely under other conditions.

HABER AMMONIA PROCESS

In the Haber ammonia process, the reaction may be written, $N_2 + 3\ H_2 = 2\ NH_3$. The technical catalytic agent is a specially prepared iron to which have been added small amounts of other substances such as the oxids of molybdenum, tungsten, or cerium, these latter being called promoters. We do not know at all why these substances act as they do, though several guesses have been made. One is that the promoter changes the relative adsorption of the reacting gases so as to make it more nearly equal to the ratio required for the reaction. A second is that the promotor decreases the adsorption of the catalytic agent for the reaction product—ammonia in this case. The third is that the promoter activates the reacting substance which is activated but slightly, if at all, by the catalytic agent.

The equilibrium conditions are much less favorable in the ammonia synthesis than in the contact sulphuric acid process. In the latter there was practically 100 per cent. conversion at 400 degrees, the lowest practicable temperature, and 95 per cent. at the normal working temperature of about 450 degrees. In the ammonia synthesis it is not feasible at present to go much below 550 degrees and at that temperature the theoretical yield of ammonia is 0.08 per cent. Increase of pressure displaces the equilibrium so that more ammonia is formed because it is the system occupying the smaller volume. At 550 degrees and 200 atmospheres, the theoretical yield of ammonia is almost 12 per cent. The data are given in Table I.

TABLE I. EQUILIBRIUM DATA FOR AMMONIA SYNTHESIS

$$N_2 + 3\,H_2 = 2\,NH_3$$

Pressure in atm.	550°	650°	750°	850°	1000°
	Percentage ammonia at equilibrium				
1	0.08	0.03	0.02	0.009	0.006
100	6.7	3.02	1.54	0.87	0.54
200	11.9	5.71	2.99	1.68	1.07

Though the yield of 12 per cent. is low, the ammonia can be removed as ammonia of crystallization by ammonium nitrate at low temperatures or by injecting water under pressure, a fresh supply of the reacting gases can be added to the unchanged nitrogen and hydrogen, and the operation can be repeated again and again until the concentration of methane and argon becomes too high. The argon was present as an impurity in the nitrogen and the methane is due to reduction of traces of carbon monoxid in the hydrogen.

The contact ammonia process is very susceptible to poisons. Among the harmful substances are sulphur, selenium, tellurium,

[illegible] compounds [illegible] many [illegible]
[illegible] minute quantities
[illegible] found almost
[illegible] so-called pure
[illegible] sufficient [illegible]
[illegible]
[illegible] value
[illegible] places in which
[illegible] where the

[illegible]
[illegible] made the

[illegible]
[illegible] however,
[illegible] measure
[illegible] years
[illegible] was

[illegible]
[illegible] that
[illegible] 200 [illegible]
[illegible] difficulties
[illegible] distinct
[illegible] necessary only to
[illegible] series

instead of through at least fifteen as in the Haber process. The pressure of liquid ammonia is seven to eight atmospheres at ordinary temperatures, and the partial pressure of the ammonia in the Haber process is 12 atmospheres while it is 250 in the Claude process. This means that most of the ammonia can be drawn off as liquid in the latter case and only a small part in the former case.

OSTWALD NITRIC ACID PROCESS

The Haber process gave the Germans a supply of ammonia in addition to the ammonia from coal; but during the war they needed nitric acid and they obtained this by oxidation of ammonia, using the Ostwald process. In 1830 Kugelmann observed that ammonia can be oxidized to nitric acid in presence of platinum. About eighty years later the process was put on a semi-commercial basis by Ostwald; but its prospects were not encouraging, until the outbreak of the war and the ensuing naval blockade made it an absolute necessity to the Germans. The nominal reaction may be written $NH_3 + 2\ O_2 = HNO_3 + H_2O$; but the real reaction is the formation of nitric oxid, which is then oxidized to nitrogen peroxid, and afterwards converted into nitric acid, as follows: $4\ NH_3 + 7\ O_2 = 4\ NO + 6\ H_2O + 2\ O_2 = 4\ NO_2 + 6\ H_2O = 2\ HNO_3 + 2\ HNO_2 + 4\ H_2O$.

The problem is complicated by the apparently simultaneous oxidation to nitrogen, a reaction which is usually written:

$$4\ NH_3 + 3\ O_2 = 2\ N_2 + 6\ H_2O.$$

It is more likely that the disturbing reaction is an oxidation of ammonia by nitric oxid, perhaps:

$$4\ NH_3 + 6\ NO = 5\ N_2 + 6\ H_2O.$$

Both reactions are accelerated by platinum; but, fortunately, the reaction yielding nitric oxid takes place much more rapidly than the reaction giving rise to nitrogen. The best results are obtained by keeping the gases in contact with the catalytic agent for as short a time as possible, which is an argument for the reaction producing nitrogen being a secondary one. If the two reactions took place simultaneously, the ratio of the two sets of products should be independent of the rate of passage of the gaseous mixture. A mixture of ammonia with 10 or more volumes of air is passed at a velocity of one to five meters per second through a plug of platinum gauze, one to two centimeters in length, and kept at 300 degrees. This gives a period of contact not exceeding 0.01 second. Under favorable conditions an 85 per cent. conversion of ammonia is claimed. Better results have been obtained in this country, with several layers of platinum gauze, the yield running 92 per cent., with a flow of 250 cubic feet per minute. The average concentration of ammonia is 10.7 per cent. A smooth platinum gauze is not effective. After some time it becomes roughened and activated. Contrary to what Ostwald had believed, a high temperature, say above 825 degrees, is better than a lower one. Phosphine is a bad poison, having a distinct effect even when present three parts per hundred million, but cyanogen compounds are not bad because they oxidize readily. Iron oxid, grease, oil, or tar must be kept away from the platinum gauze and a new gauze should be washed with pure gasoline or ether before being activated. Ammonia from any source can be used, though Landis claims that the platinum must be activated anew when changing to a different ammonia.

SABATIER HYDROGENATION PROCESS

About twenty-five years ago, Sabatier and Senderens, in France, discovered that reduced, pulverulent nickel will cause hydrogen to combine with ethylene or acetylene, forming ethane. This has since been developed into a general hydrogenation process. The principle of the method is a simple one. The vapor of the substance to be reduced is mixed with hydrogen and passed directly over specific metallic catalysts maintained at temperatures usually held between 150 and 300 degrees. A comparatively recent technical development of this process is the hardening of oils, converting oleic acid or olein, for instance, into stearic acid or stearin by the action of hydrogen on the liquid unsaturated oil in presence of a suitable catalytic agent. In 1908 Paal proposed using a colloidal metal as the catalytic agent at ordinary temperatures. Colloidal suspensions of platinum, palladium, osmium, and iridium have been made, of which the palladium hydrosol seems to be the best. When hydrogen at ordinary temperature is passed into glycerids of the fatty acids to which some palladium hydrosol has been added, a reduction takes place and the oil becomes solid. It is more satisfactory to precipitate the metal on an inert base such as magnesia or kieselguhr. A cheaper and apparently better method is to use nickel as a catalytic agent for the hydrogenation of liquid, unsaturated esters, the reduction taking place at about 250 to 300 degrees. "Crisco" is a hardened oil.

SURFACE COMBUSTION

The subject of surface combustion has been developed by Bone in England and by Lucke in America. If an explosive mixture of a combustible gas and air is pressed through the pores of a granular, high-melting solid, and if the issuing gas be lighted, it will speedily raise the granular solid to incandescence if the conditions are right, after which the heated surface will accelerate the rate of combustion so much that the whole of the gas will be burned at the surface of the solid and we shall have what has been called flameless combustion. As a matter of fact, there is flame; but the flame is so short and the light from the incandescent solid so intense that there seems to be no flame. The combustion takes place only at the surface layer of the granular solid, but all over the surface and not as flames between solid particles.

The advantages of this surface combustion are an intense and a localized heat, combustion with minimum excess of air, and the development of a large amount of the heat as radiant energy. By passing the explosive mixture through a porous diaphragm we get an incandescent surface which can, if need be, be held, glowing side down, over a solution which is to be evaporated. In this way, it is possible, for instance, to evaporate a water-glass solution without danger of bumping. The sodium silicate forms as a solid film on the surface of the solution and can be removed from time to time. This form of heating has proved very successful in making candy.

The granular mass may be piled in around a crucible or around boiler tubes giving an extremely high efficiency. The maximum temperature depends on the working conditions. The choice of refractory material is determined by the temperatures involved. Under ordinary conditions, calcined fire-clay, ganister, etc., are used; but, when high temperatures are in question, practically all solids are eliminated except calcined magnesia and carborundum. Attempts are now being made to substitute an atomized liquid fuel for a gaseous fuel. It is stated that the most successful applications of surface combustion to large-scale work are where the heat is radiated very quickly so that the temperature of the refractory does not rise unduly—with steam boiler tubes packed in refractory. material for instance. Surface combustion furnaces have proved very useful in annealing shell.

Since an explosive gas mixture is used, it is necessary to keep the flame from working back and burning in the mass of the refractory instead of on the surface. Bone does this by regulating the rate of flow of the gaseous mixture. Lucke has described several ways of doing this by special construction of the heater.

WELSBACH GAS MANTLE

The invention of the gas mantle made it possible for gas to continue to compete with electricity as an illuminant. The best results are obtained when the Welsbach gas mantle consists of 99 per cent. thoria and one per cent. ceria. Pure thoria gives a relatively poor light, but the continuous addition of ceria gradually increases the luminosity to a maximum of tenfold when one per cent. is present. Any further addition then diminishes the luminosity until, with 10 per cent., the difference in effect is inappreciable. In present-day manufacture, the cotton, silk or ramie web is impregnated with a 25 to 33 per cent. aqueous solution of thorium and cerium nitrates in the proportion of 99 to 1, together with a little hardening medium, such as beryllium nitrate, if necessary.

We are dealing with surface combustion both in the case of the lime light and of the Welsbach mantle, as is shown by the rapid decay of the light of the lime-light owing to sintering and the similar though much slower decay of the light of the Welsbach mantle. Mantles of magnesia and lanthana give a good light when new, but the light decreases as the surface becomes glassy. While a thoria mantle reaches a high temperature, its emissive power is low. Ceria has a high emissive power in the visible spectrum, but the energy of radiation is so great that the temperature of a ceria mantle does not rise high enough. Starting with thoria and increasing the amount of ceria increases the emissive power but lowers the temperature of the mantle. The maximum luminous efficiency is obtained when the rise of visible emission due to the ceria is balanced by the drop in the temperature of the mantle due to the increased radiation. The ceria may form a solid solution with the thoria but there seem to be no data to show whether equilibrium is actually reached in the mantle.

FUTURE DEVELOPMENTS

In the few minutes that are left to me, I should like to say a word or two about possible future developments in contact catalysis. I am practically quoting from a talk I gave in New York at the International Meeting of the American Chemical Society. The organic chemist is only just beginning to use catalytic agents with zest and we may expect at any time to hear of improved methods of manufacture, such as the recent synthesis of maleic acid from benzene by the Barrett Company. That reminds me that one per cent. of malic acid added to sugar is said to duplicate maple sugar exactly, so that when malic acid gets cheap enough, we can dispense with maple trees and the term "sugar bush" will occur only in novels.

The problem of a future supply of motor fuel is a very serious one. One man believes that the solution lies in the hydrogenation of coal. Others think that a better yield of alcohol by fermentation will solve the problem. Still others hope to prepare some new combustible liquid from tropical vegetation and from corn-stalks. I do not know which is the right solution or whether these three and still other methods will contribute in maintaining an adequate supply of motor fuel; but all that have been suggested require the use of catalytic agents.

If we could produce what is popularly known as cold light, equaling the firefly without adopting its methods, that would make possible an enormous decrease in the power necessary for lighting purposes. Cold light will come some day and we know enough now to predict that we shall make use of a catalytic agent to speed up the reaction which gives rise to the light. If we could cause the rain-clouds which now pass tantalizingly over many of the arid regions to precipitate, we could increase the fertility and consequently the value of these lands to an unbelievable extent. This is not "rain-making" in the popular sense; but is a matter which is quite within the limits of accomplishment.

I do not know when, or to what extent, the chemist is going to make available the energy in the sunlight or the atomic energies which have been made manifest to us by the properties of the radioactive substances; but I do know that these things, when they come, will involve catalysis. It is because we cannot speed up atomic disintegrations that we cannot utilize the energy locked up in the atom.

Vitamines are a mysterious set of substances which certainly act catalytically if we make our definition broad enough. I do not see how they can ever be used to generate power directly, but we are only just beginning to appreciate the part they play in the health of the individual. If we can raise the standard of general health and can decrease the amount of sickness, we shall have done more for the happiness and prosperity of the world than could be accomplished by almost any accumulation of capital. This is one of the most important of the problems that confront the chemist.

I have, of course, kept one of the very interesting theoretical points for the last. Sabatier, in France, has opened our eyes to the extraordinary possibilities which catalytic agents have in helping us to make organic compounds. J. J. Thomson, in England, has proved that catalytic agents may displace equilibrium, contrary to what has been believed as dogma by Ostwald and his school in Germany. Reid, of the Johns Hopkins University, has apparently furnished the missing experimental proof. He passed a mixture of the vapors of ethyl alcohol and acetic acid for 24 hours over silica gel as catalytic agent and during the whole of that time he obtained about 10 per cent. more of ethyl acetate than corressponds to the theoretical equilibrium. These experiments have not yet been repeated by anybody else and there is always the possibility of an unsuspected error. The results seem to me theoretically possible and I should like to have you consider what they mean in case they are confirmed. Of course, nobody cares about an increased yield of ethyl acetate; but think what a displacement of 10 per cent. in the right direction would mean in the synthesis of ammonia, to take a single instance! It would revolutionize everything. Such a thing may not be possible, but it looks as though this was a legitimate dream to-day and the legitimate scientific dreams of to-day are the successful technical processes of to-morrow.

DISCUSSION

Mr. A. E. Blake:* When a homogeneous mixture of air and gas is projected into a pile of granular refractory, or into the pores of a refractory diaphragm, so that surface combustion results, I do not think it is correct to refer to the visible zone of bluish light, when any does happen to be visible, as a flame. With a proper mixture, the chemi-luminescence which may be visible after the refractory has reached a fairly high temperature very probably exists outside the zone of actual oxidation, which, under the conditions, is very small indeed. The luminescence is undoubtedly due to ionization in the products of combustion and is probably comparable to that produced in a Geissler tube.

While I do not know of any definition of flame which would be classed as technical or scientific, we can all call to mind the painstaking descriptions of flame which generally occur in one of the opening chapters of the text-books on general inorganic chemistry. These descriptions refer to what takes place about a candle wick, a Bunsen burner, or other common illustrative case. Attention is called to the zone of pure combustible gas—or mixture of it with some air, but not enough to make an explosive mixture—as the central portion; the visible jacket in which oxidation occurs; and the surrounding zone of hot products of combustion.

A surface-combustion fire would indeed be a special case of the foregoing, since the mixed gas and air molecules are already within what might be called molecular striking distance; so that as each successive moving lamina of mixture arrives at the position where ignition temperature is attained, a reaction zone so thin as certainly to be invisible is formed. The distance is very small indeed between oncoming mixture and products of combustion leaving the reaction zone. Bone's work with porous diaphragms showed this. Furthermore, the surface combustion zone is in no way dependent for oxygen upon the surrounding atmosphere, which could just as well be CO_2 or N_2, so far as having any influence upon the rate of combustion goes. This alone makes it very different from the candle, wood, or lamp flame, since these get all their oxygen from without, while the Bunsen burner, and a multitude of commercial pressure burners having some air supplied to the stream of gas to be burned, also must depend to a greater or less extent upon secondary air provided by means of open ports and draft.

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According to some of the dictionaries, it would be proper to call the aurora borealis flame, but it seems to me that the chemists and physicists would be warranted in adopting some technical definition in view of the great amount of disagreement which now exists over the matter. My own definition would be made up from the discussions already referred to as generally appearing in the chemistry texts.

DR. WILDER D. BANCROFT: As regards the low temperature, I think that I myself said that platinum black will cause oxygen and hydrogen to combine at low temperature. Most catalytic agents act more effectively at high temperature than at low. As regards surface combustion, the question turns on the definition of flame. If you limit the word to the kind of flame that a candle gives, then surface combustion is flameless combustion, because the flame you ordinarily see in a candle is simply incandescent particles of carbon. But if you define flame, as I should, as light produced during or by combustion, then I think you are wrong. The inner core of a Bunsen burner, for instance, gives a blue flame. If we pass carbon monoxid and oxygen through a refractory we may have a long blue flame or a very short blue flame; but those are the only alternatives. If a man does not look at the short flame very carefully, he may think that there is no flame. Actually, I am told that there is a short flame. It is chemi-luminescence. If you let me make my own definition of flame, I shall win, of course.

MR. A. E. BLAKE: The theory of surface combustion has been a hobby of mine for a long time, and in describing the process

I have generally found it easiest to differentiate it from ordinary flame, with which everyone is sure to be familiar.

If you wish to maintain that chemi-luminescence in hot gases constitutes flame, there are many special cases to be explained away. Pure hydrogen and pure air combine at atmospheric pressure with so little visual evidence that one of the hottest flames known is in danger of being ruled out. On the other hand, we might pass air, nitrogen, or argon through a heated tube and raise the temperature of the gas to such a degree that upon being projected from the tube, a chemi-luminescent glow would be visible, yet we would hesitate to tell a layman that this is flame.

DR. WILDER D. BANCROFT: I don't know about that because I do not know whether you ever get pure hydrogen and dust-free air. But again I would rather select my own fighting ground. Take carbon monoxid and oxygen and we know this burns with a blue flame. I do not think that your point is well taken because, according to you, burning pure hydrogen in pure oxygen would be flameless combustion, and yet it certainly would not resemble in any way the flameless combustion that I call surface combustion. It may be all right to say flameless combustion when you are talking to laymen who have never seen a Bunsen burner, but I was talking to chemists and engineers.

MR. A. E. BLAKE: The common difficulty in a case of this sort is in the habit of overlooking the difference between a stream of pure gas issuing from a tube and burning with a flame, and a stream of theoretical, homogeneous mixture of air and gas.

In the first case, carbon monoxid burns with a very characteristic blue flame, which is responsible for the distinguishing term "blue water-gas." I have seen cold, black burner orifices discharging theoretical air-gas mixtures into hot furnace interiors where no refractory diaphragm or lump refractory is used at all, and by looking directly into the cold burner nozzle through the zone of combustion, it was impossible to see any luminescence whatever. This was with natural gas as fuel, which generally requires about ten volumes of air to one of gas for a theoretical mixture. If there could be delayed combustion when such a process is used, this should be a likely place for evidence to be apparant.

I have seen water-gas and air mixture projected into granular refractory, maintained at high temperature by the combustion, with no visible gas luminosity, even though the fuel carries high percentages of carbon monoxid.

DR. WILDER D. BANCROFT: Do you think that carbon monoxid does not burn with oxygen in a blue flame?

MR. A. E. BLAKE: The carbon monoxid issuing from a pipe and burning in air gives a blue flame. Natural gas and most artificial gases give red, yellow, or white flames, according to rate of combustion. The first case is a little harder to explain than the second.

DR. WILDER D. BANCROFT: I have never tried an explosive mixture of carbon monoxid and carbon and oxygen; but I feel certain that it burns with a blue light that I call flame. The blue cannot be due to incandescent carbon.

MR. A. E. BLAKE: We don't know exactly what causes the luminosity in hot gases, or do not take the trouble to learn the cause, if it is known; so we call it "chemi-luminescence." It is appropriate and convenient. This applies when we omit certain well-known causes, such as presence of dust particles—either of carbon, metals such as copper, the alkalies, alkaline earths, etc. These characteristic "flames" can be made with the assistance of a hot stream of inert gas, or in the electric arc, where nothing occurs to which we would refer as combustion.

DR. WILDER D. BANCROFT: Chemi-luminescence is a good non-committal term, like catalysis and some others. I do not really see why there should be any fundamental difference whether you have a large amount of carbon monoxid, or a large amount of oxygen, or an explosive mixture. The only difference I can see, is that with a large amount of carbon monoxid and a very high temperature the carbon monoxid might break down into carbon. That has been actually done, I believe. If there is a solid in the gas mixture, the color will not be blue at that temperature. Consequently, it seems to me that the blue flame in the case of carbon monoxid must be chemi-luminescence due to the reaction and if it is a case of chemi-luminescence due to the reaction you are going to have it no matter how pure the gas is or whether you have a perfect mixture or not.

MR. A. E. BLAKE: Then we are back to the question as to whether chemi-luminescence in gases constitutes flame, or simply a phenomenon often observed in combustion of gases.

DR. WILDER D. BANCROFT: No, it is a question of the definition of a flame.

MR. J. B. CRANE:* As I understand the description, catalytic agents have been used so far mostly with gases. Is there any arrangement by which the same can be carried on with liquids or solids?

DR. WILDER D. BANCROFT: Yes. I merely spoke of gaseous reactions because those have been worked out more completely on a technical scale. I thought I could get illustrations there that would appeal to this audience probably better than from the other. Of course, we have no end of cases of catalysis in liquids; but there we are more apt to use dissolved catalytic agents. The use of sulphuric acid in making ether is a case in point. There an intermediate compound is formed. The inversion of sugar by hydrochloric acid is another case. There are no end of reactions in liquids, that involve catalysis. The hydrogenation of oils is an important technical process.

Let me add just one thing more about that question of flame, which is again a question of definition. Suppose you put salts in your Bunsen burner. If you do not put in much, I imagine that you do not change the temperature of the flame to speak of.

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*Engineer, George T. Ladd Co., Pittsburgh.

If you put in sodium salts you get a yellow, which might be due to incandescent particles, though I do not believe it. Put in copper and you get a blue; put in strontium and you get a red. These flames can not be temperature effects because you are getting the blue, red, and yellow at the same temperature. I think that these are all cases of chemi-luminescence. If we have luminescence with copper, sodium, and strontium, and so on all down the line, personally I am inclined to think we have it with carbon monoxid.

MR. A. C. FIELDNER:* By-product coke-oven gas contains from two to five per cent. unsaturated gases, principally ethylene. The ethylene may be converted to alcohol by absorbing it in concentrated sulphuric acid, forming ethyl hydrogen sulphate and subsequently hydrolizing to form ethyl alcohol. Propyl alcohol may be produced in the same manner from propylene. Isopropyl alcohol is now being made by the Standard Oil Company of New Jersey from the propylene in waste still gases. In England, yields of four gallons of ethyl alcohol per ton of coal carbonized have been obtained from coke-oven gas, in a small experimental plant.

On this basis the liquid motor-fuel yield from a ton of coal can be more than doubled. Present practice yields approximately three gallons of light oil per ton of coal. Future practice may add to this amount four to five gallons of alcohol, provided a suitable catalyst is discovered to produce direct combination of ethylene and water, thus eliminating the expensive sulphuric acid process of conversion.

MR. J. E. BABB:† Would two per cent. of malic acid give you home brew?

DR. WILDER D. BANCROFT: I don't know. Simply as a guess, if one per cent. gives you Vermont maple-sugar I would expect two per cent. to give you at least hard cider.

*Supervising Chemist, Pittsburgh Experiment Station, U. S. Bureau of Mines.

†Superintendent and Director of Chemical Laboratory, Waverly Oil Works Co., Pittsburgh.

DR. K. F. STAHL:* Dr. Bancroft, you mentioned silica gel. Do you know for what it is used?

DR. WILDER D. BANCROFT: It has been proposed to use it for drying the air blast in furnaces and for many other purposes. I do not know to what extent it is in actual technical use at present.

DR. K. F. STAHL: It is made by the Silica-Gel Corporation, a subsidiary of the Davison Chemical Company, of Baltimore. I believe they obtain it as a by-product in the decomposition of silicon fluorid, SiF_4, with water. The two products formed are hydrofluosilicic acid and silicic acid the latter in a gelatinous state. The silicon fluorid gas is formed when phosphate rock is acidulated with sulphuric acid.

MR. J. E. BABB: Is there such a thing as a mass catalyzer? For instance, soap, where the reaction takes place very slowly, but, if you leave some soap in the kettle and make up a new batch, the reaction is accelerated immediately. Would you call that simply acceleration or is it mass catalysis, or does it have any catalytic function?

DR. WILDER D. BANCROFT: I don't know. We do know that with different solvents you may get the same reaction running to the end in all cases and yet have variations in the rate of 1 to 1000. The soap that you already had there possibly acted in the nature of a solvent. You cannot call it mass action because the soap is your product, and would tend to retard the reaction rather than accelerate it. It might perfectly well be that it acted somehow in the nature of a solvent.

MR. F. F. ESPENSCHIED:† I could not quite follow the catalysis idea in rain-making. Does Dr. Bancroft mean to suggest that there is a catalytic agent in the formation of rain?

DR. WILDER D. BANCROFT: Isn't that more a question of physical than chemical reaction? Hydrogen and oxygen ought to react, and do not unless you put in a catalytic agent. The drops of water in a cloud are not a stable system and they ought to coalesce and come down; but they don't. If you can put in something that will cause them to coalesce, I don't know why you should not call that catalysis.

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*Consulting Chemist, Pittsburgh.

†District Representative, Commercial Truck Company of Philadelphia, Pittsburgh.

MR. F. F. ESPENSCHIED: Isn't it an accepted fact that precipitation is caused by lowering the temperature of saturated vapor? If a catalytic agent is required how does Nature provide such an agent? Can an electrical discharge or the noise of thunder be considered as such an agent?

DR. WILDER D. BANCROFT: I am not talking about unsaturated water vapor but of a condition where you have suspended drops of small particles of water—fog that may stay up in the air indefinitely. If you can remove or cut down whatever it is that prevents those drops from uniting, then they will do what they ought to do. We all know that small drops are instable and tend to grow into large ones. In the case of a cloud, that does not take place at any appreciable rate if you do not get rain. If you can put in anything which causes those drops to coalesce it is going to rain. If you do that and the thing you put in remains unchanged, I don't know why that is not catalysis.

THE DEVELOPMENT OF THE STEEL SALESMAN

By A. E. Crockett*

Several weeks ago, our honored President, Mr. Danforth, and our amiable Secretary, Mr. Treschow, coming upon me after I had had my lunch (and was, consequently, good natured) insisted that it was about time for me to do something for the Society--calling my attention to the fact that my continued absence from meetings and the Society rooms was causing them much concern—and demanded that I prepare something not only edifying to them, but possibly encouraging to the members. This, gentlemen, is my reason for being here this evening to talk on the development of the steel salesman. I do not know just why they limited me to this narrow field, but, as they possibly know my limitations better than I do myself, they did not think it wise to give me any greater latitude.

Some wise philosopher has said that, after all, men are only children grown up. I do not know how many fathers there are here, but I think we all agree that the perfection of the child, young or old, is attained only through training. And what is training? Just line upon line, precept upon precept—and these lines and precepts, to attain the high mark, must be the best, and as modern industry demands the best in everything, it is bending every effort to see that salesmen, as well as others, are securing this. This perfection which we are demanding is not the realization of an over-night dream, but is the product of the state of the art itself.

In the strength of yesterday and the hope of to-morrow, we labor to-day. The physiologist tells us that our strength is only as we exercise, whether it be physical or mental. The philosopher proclaims, "Hope springs eternal in the human breast;" and the pessimist, "Hope deferred maketh the heart sick." I rather imagine you are wondering just what I am driving at. These proverbs all relate, however, to the human being, and this is what a salesman is at least supposed to be; and if he ever intends to be any kind of a salesman, he must be constantly developing. How well he develops depends on his native ability, his opportunities, and his purposes.

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*Manager, Bureau of Instruction, Jones & Laughlin Steel Co., Pittsburgh.

So far as his training is concerned, a salesman in relation to his company incorporates two purposes. First, the purpose *of* training the salesman, which relates directly to the man himself—that is, his individuality. Second, the purpose *for* training the salesman, which relates directly to the company—that is, better fitting him to represent his employer properly.

It is generally admitted that the average man is a lover of ease, comfort, and pleasure, and, because of these natural desires, too frequently he seeks the line of least resistance in his daily activities and, too often, is grooved in his effort, with the result that many of the better things of life are entirely overlooked or passed by.

Not many years ago, as we count time, the overshot waterwheel was the medium of power; the wheelbarrow and cart, the mode of conveyance; and these, the accessories of the blast-furnace. Steel, as you and I know it to-day, was unknown. Iron (laboriously fashioned) was the order of the day and all the time the world going on. Man, seeing needs for greater things, and his inventive genius being stirred, brought forth devices which in themselves widened the vision, and increased demands at every step, resulting in the complications of modern industry and giving birth to Bessemer and open-hearth steel. As a result of this progress, a higher order of intelligence is necessary in its direction, and greater exactness in its application.

We have only to look at the development of the industry from its mechanical side to find the necessity for the development of the salesman. We all realize that the product must precede the salesman—that is, its construction, manufacture, or fabrication. But we also realize that the more intricate the product or machine, the more highly trained must be the man who presents it to the buyer. The realization of this important factor is very modern.

As a matter of fact, it is only within the last fifteen years that a school was deemed necessary and was established for the direct training of steel salesmen, and right here I want to give recognition to one of our own members, who stands as the dean in this field. I have reference to Mr. James M. Camp, on whose shoulders was placed the responsibility of developing a system or method for teaching salesmen the intricacies of the production of steel. The responsibility of this work has been a very serious matter to him—and I think rightly so—for through his methods is the man on the firing line better able to present his product and at the same time aid the buyer, not only in understanding the product which is being offered to him, but in giving many helpful suggestions for its working.

Coming down to the man himself, we all admit that the prime requisite in any steel salesman is strong moral character —this admits of no argument. The second is that he should possess a good academic training; the third, that he must have natural inclinations, which some of you will call "selling instinct." Then he must possess resourcefulness; and, finally, a knowledge of how the product is manufactured. Having all these qualifications, it is also necessary that the man be willing to be a continuous learner. This constant learning is acquired through books, through contact with people, and through his power of observation. This willingness to be a learner is of vital importance, for if the man is not willing to continue to grow, all knowledge attained gradually atrophies.

As each one of us realizes, a man either goes ahead or goes back; there is no common middle ground for him to stand on. Consequently, in addition to his being a learner, he must be a thinker. He must think in fundamental units, in a basic manner, and not only must he think in this manner but because he does think in this manner he must develop his facts in a logical sequence; and, in the developing of his facts, he must do it with a definite purpose in view, and that is to reach a conclusion on which to predicate his acts. Thus, having acquired information and thought about it and, having come to a definite conclusion, conclusions in themselves will amount to nothing if he does not become a doer, and the results which he will obtain will depend upon his doing things in a systematic manner. He has before him his territory which possesses large possibilities. Many calls must be made—monthly, quarterly, semi-annually, or anuually. Therefore, taking his territory as it stands, he must arrange his daily work over a year, so that there will be no working at cross purposes. Having systematically arranged his territory, he must go at his work in an earnest manner, being optimistic and aggressive; and, not only must he be optimistic and aggressive, but he must be efficient to the extent of possessing the power to convey to the purchaser an idea of the full merits of the product he is offering, and being able to counsel with the buyer as to the general trend of trade conditions, so that the buyer will at all times feel that this man is a direct aid to him, enabling him to make money for his concern, which is, after all, what both are trying to do.

With this broad mental picture of the fundamentals of the man and his training, let us for a short time consider the specific development of the steel salesman in relation to what he is selling.

A clear understanding of the art of the manufacture of steel should be obligatory. This should consider the mechanical equipment employed, the difficulties encountered, the methods or systems of control—in fact, all agencies involved in the production of the finished product. The man must first be given to understand that the manufacture of steel is but the working of natural laws in a normal manner; and, in order that these natural laws can be comprehended or understood, there is the science of chemistry, by which he is able to determine their functioning, the elements involved, and their relation to each other—particularly the predominant elements, such as iron, carbon, manganese, sulphur, phosphorus, silicon, oxygen, hydrogen, nitrogen, and many others.

The salesman, having this fact clear in his mind, is then better able to progress with his work. I do not mean that he will be able to go into a laboratory and conduct analyses, for this is a profession requiring a man's undivided study and time for a good many years, but a broad understanding of these vital facts makes him better able to understand why iron-ore is the foundation on which rests the entire industry of steel manufacture.

Understanding the state in which iron-ore largely exists, where it is mixed, how it is mixed, graded, and transported, his picture commences to have its first lines drawn in. He has learned, because of his knowledge of chemistry, that iron-ore of itself cannot be changed into another form or shape without the aid of heat; consequently, he is made to understand that heat for reducing the ore can be obtained only from coal; and this, after its conversion into coke.

Having been shown how coal is mined and converted into coke, he must search still further, for he understands that the coke in itself does not contain the necessary element or elements to complete the process of reducing the ore to pig-iron. Further study develops the fact that limestone is essential to placing the elements in such a state that in assuming their proper relation for natural functioning, the impurities will be driven or absorbed from the iron, resulting in a product for the next step in the process. Thus, to round out his thought, there should be presented to him the quarrying of limestone and its preparation for use as a flux, whether in the blast-furnaces or open-hearth furnace.

Naturally, the student is very much interested in the mechanical agencies for this reduction of iron, with the result that the blast-furnace is figuratively built, and, because we learn much by observation, the student should be given an opportunity of analyzing this furnace and all the mechanical equipment associated therewith. This is true not only of the blast-furnace, but of every other mechanical operation throughout the process of steel making. The Bessemer converter, the open-hearth furnace, the soaking pits, the blooming mills, billet mills, bar mills, gas-producers—in fact, all mechanical equipment—should be inspected and analyzed, preferably under the direction of those whose daily vocation brings them into immediate association with the equipmnt utilized.

Then, as to the actual making of the steel. The man should be shown the pig metal delivered to the mixer, and from here transported to either the Bessemer converter or the open-hearth furnace, depending upon which quality of steel is to be made.

If it is the open-hearth process, the two types should be very clearly explained to him. Through his powers of observation and by the word of the instructor he can be very clearly shown the reactions taking place in the furnaces, see the materials used for the creation of the slags, and how the slags are formed, and, carrying the process further, the tapping of the furnace, the recarburizing of the metal, its teeming into the ingot molds, as well as the stripping of the mold from the solidified ingot. If the process is that of making Bessemer steel, the very attractiveness of the process rivets the attention of the student, particularly as he sees the long flame interspersed with myriads of sparks belching from the mouth of the converter, giving rise in his mind to questions as to the cause, as well as the possible effects.

Right here, gentlemen, I want to say I believe that every man should be encouraged to be a living interrogation point, not only when passing through the direct course of the manufacture of steel, but in all walks of life.

Coming back once more to our subject, the man having seen the process, so far, has only had his appetite whetted. He sees the stripped ingot deposited in the soaking pit, to remain until such time as a uniform temperature has been established throughout the mass and the steel presented in such a state that, when delivered to the blooming mills, it can be reduced to a bloom without splitting, tearing or mushing. Thus the man proceeds to follow the bloom down to its billet stage, and its ultimate shaping into I-beams or channels, or down to the most delicately drawn wire. Following it in another channel, he may see it go into sheet bars or skelp, thence to pipe or sheets—later to receive a coat of tin, and ultimately to be the receptacle for preserving the food which forms our daily sustenance.

Any man following these processes under careful guidance and direction, should obtain a broad understanding of how steel is made.

Every opportunity should be provided for the inspection of the product of the various mills, for the salesman has learned by this time that steel making is not an exact science, and there are difficulties to be overcome all along the road. He has been shown the extreme care with which the various operators proceed in their work, to the end that when the product ultimately reaches the shipping yards it will be available for the purpose for which it was manufactured and for the purpose for which it is intended. Of course, along the way he finds that it is necessary to crop the bloom, to chip the billets, to straighten the bar, and, when necessary, to cut the requisite specimen for testing, to see that it meets all of the requirements of the modern specification.

The end is not yet, for the material that leaves the rolling-mill is not in shape for ultimate use, and is subject to further physical change. Consequently, the man must have his vision broadened, so that he may be able intelligently to study the uses of steel—whether plainly forged, drop forged, worked in high-speed automatic machines, heat treated, case hardened, or subjected to other operations before reaching the consumers.

It has been well stated that no sale is completed until the seller has received his money for the product sold. Consequently, the matter of credit, must be given careful consideration and interpreted by those who are expert in this line, who will show the relation of the man in the field to this important point, and, in addition, give valuable hints and suggestions, even to finally securing a financial settlement.

Claims and complaints are ever with us, either for real or imaginary causes, and a man must be given the knowledge as to how to proceed intelligently in adjusting matters of this character. In the light of all the knowledge he has gained in reference to manufacture, he should be better prepared at least to make investigations and formulate a report which will permit the interested parties at the mill or office to form conclusions tending to a satisfactory settlement for all parties concerned.

The ever widening control of our railroads by the government complicates transportation problems. To the end that a broad understanding may be gained, the salesman should receive from the traffic manager a lucid and concise statement of facts relative to freight movements and the manner in which the salesman can be of assistance to the traffic manager.

There are other things that should be considered in this program. The average man knows that a sale is affected by law, and that there are certain prescribed forms which the law demands that we shall observe, both as to the meaning and the scope of any contract, but the full import is not grasped. Consequently, the legal department should give a good summary of what a contract means, what a delivery means what is meant by terms of sale, what is meant by a promise, how long an option can be given for and how it can be withdrawn, and when it can be withdrawn and when it can not. All these are elemental things that we do every day because some one else did them before and we follow without reason. I am a Yankee and have a Yankee's instinct to want to know why. I think if we can answer these whys that are simply taken for granted, we will strengthen the man as he goes forth to his daily work, add to his confidence, and make him feel that he knows what he is doing.

A trained salesman going abroad should represent good reliable people; concerns who are ready and willing at all times to fulfill the offers and promises made by their authorized representatives. Performance on the part of the manufacturer is most important.

In South America, where I have traveled extensively and reported to our Government on the construction materials and machinery markets of the several countries, the majority of the merchants look to Pittsburgh manufacturers for the last word in steel making and sales conditions.

Generally the trade, especially in Latin America, looks to Pittsburgh for experience, specifications, fair prices and deliveries, and all that is foremost and right in commercial procedure. Manufacturers should remember this and do everything possible to maintain the confidence gained in this regard during the World War.

DISCUSSION

Mr. H. R. Thayer:[*] During many years of college instruction my efforts with the members of the rising generation have been entirely confined to teaching them the scientific truths which the speaker has mentioned. I have not had a great deal to do with teaching them how to sell goods, but I notice that quite a proportion of our graduates take up that line of work, and in a great many cases they find it more remunerative than the bare technical end. I have noticed particularly in the last few years that more and more corporations, and especially the higher grade of corporations, have taken up two policies. In the first place, they aim to secure men of the highest possible equipment, a good many of them making it a point to take only technical graduates. In the second place, their salesmen are instructed to sell goods only in the location where they will give satisfaction.

I can remember when the word salesman used to be a term of reproach because a salesman who could talk would get you to buy something whether you needed it or not. The present idea is to see that the customer gets exactly what he is after—as the speaker very properly puts it, to make both parties secure a reasonable profit from the transaction.

I enjoyed the paper very much and it is so complete that I feel entirely unable to add anything to it.

Mr. E. O. Mueller:[†] One question in my mind concerns me vitally at the present time. Unfortunately I was not able to hear the first part of the paper and it may have been answered there. I presume the manner in which the company with which you are connected trains its salesmen is substantially the same as that used by other large steel companies. Is it customary or is it obligatory that your salesmen be taken from the ranks of your own company and put through that school or do you make exceptions where a man has had a reasonable amount of experience, say in the manufacture or design of apparatus for steel manufacture and then has had sales experience along other allied lines? Do you put such a man among your sales force or is that not usually done?

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[*] Markhart-Thayer Engineering Co., Pittsburgh.
[†] Engineer, Pittsburgh.

MR. A. E. CROCKETT: The rank and file of our salesmen I think can be assigned to the class that have come up through the office, out of the branch offices, through the home office, through the mills or other sections. No salesman ever enters the school who has not first proved that he has the natural sales instinct and is a man we wish to continue with the company.

Does that answer your question?

MR. E. O. MUELLER: Not altogether. Suppose a man applying to your company is familiar with the problems of the manufacture of steel from years of experience, either from the practical operating end or the designing end, and he has had other sales experience but not in steel. How do you test the ability of such a man, and would you put him on or would you not?

MR. A. E. CROCKETT: That is a matter of administration that is outside of my educational work and I am afraid I cannot give you the information you desire.

MR. J. O. DURKEE:* I would like to ask about that sales instinct. What relation does it bear to selling? In addition to knowledge of and confidence in the firm or manufacturer, a knowledge of the goods presented, a knowledge of the customer's need, clean moral character, and a good personality, is there a distinct sales instinct?

MR. A. E. CROCKETT: I am afraid I cannot tell you what sales instinct is. It is one of those things that can be felt, yet not described. As an instance, take electricity; I can feel it and see its effects, but cannot tell you what it is.

*Technical Editor "Coal Industry," Pittsburgh.

Incorporated, however, in that which we call "selling instinct" I would embody the ability to say no, and the keen power of observation which projects the man's mind to the point where the varied activities of life synchronize with the product the man is selling. As an instance, you may see a factory where condensed milk is being prepared. If you are a tin-plate salesman, you do not stop at the mere fact that condensed milk is being produced, but project your thought to the point of the package in which the milk is placed for delivery—in other words, tin cans—and then back to the plate from which the can is made.

The salesman should possess the spirit of absolute fairness in all his dealings—absolute truthfulness. These qualities being inherent in the man, he is able to detect any deviation on the part of the man with whom he is dealing.

These things, I believe, gentlemen, belong to the selling instinct.

MR. E. F. FORBATH:* How do you gain and how do you improve upon sales ability—not the ability to develop live prospects, but the ability enabling you to close orders with prospects?

MR. A. E. CROCKETT: I know of no royal road to salesmanship. Possessing the qualities already set forth in this talk—that of absolute knowledge of your goods, what they will do, knowing that an equitable profit (always essential for the continuation of any business) is included in your price—added to these, a general knowledge of your customer's product and its use, practice or experience alone can give the salesman the power to secure the order that is desired.

MR. A. STUCKI:† I think Mr. Crockett hit the nail right on the head just now. A salesman must know his business; he must know that he is right; he must know that his goods give full value; he must be convinced that his firm is the best—but that is not enough. He must convince the other fellow of these facts, and to do this it is necessary to put his whole soul and a good deal of enthusiasm into the bargain.

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*Pittsburgh Manager, Granite City Industrial & Development Co., Pittsburgh.

†Consulting Engineer, Pittsburgh.

MR. G. H. DANFORTH, *Chairman*:* We have with us one who has traveled over a large part of the globe in connection with steel, in both an engineering capacity and sales capacity—Mr. Ewing, and we should like to hear from him.

MR. W. W. EWING:† In the first place we must represent the proper people, and by that I mean that we must know we have people at home who are ready and willing at all times to back up all our offers by performance. Performance is the most important thing in the delivery of an article such as Pittsburgh's steel products. I did not expect to talk, but I can say that here in Pittsburgh we have the foundation of one of the strongest institutions in the world. All over South America and Europe where I travel they look to us for experience, for the development of everything in the way of metallurgical manufactures; but we should always remember that we can do these things, and do them in an honest, upright, straightforward manner, just as Mr. Crockett has said, so that the confidence that the world has in us may be maintained. They do look to us in Pittsburgh to give them the experience and the specifications and the delivery of all that is right and honest in the steel industry.

MR. G. H. DANFORTH, *Chairman*: Has any one else anything to say or any question to ask? If not, I might wind up this discussion by telling of a funny experience I had some years ago, not as a personal accomplishment but as an illustration of Mr. Crockett's point. I was in Hollidaysburg and I heard of a firm in Altoona that was going to put up a furniture warehouse. The two partners happened to be boys from Hollidaysburg. I got a mutual friend to call one of the partners and arrange an interview for me. I found a gentleman who realized that he had to have a new building for his furniture business but he was not very well posted as to how he ought to go about it. He had a set of plans which he said I could bring to Pittsburgh and

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*Structural Engineer, Jones & Laughlin Steel Co., Pittsburgh.
†Export Department, Jones & Laughlin Steel Co., Pittsburgh.

figure. His parting shot was, "If you see anything in those plans that doesn't look right, please let me know." We had the estimates made up, and the comments from the estimating room were decidedly hot—among others, that the building was highly dangerous and would probably fall down before it was up. Noticing on the plans the name of an "architect," I was wary of making any comments on the design, but I wound up with the statement that there were a few things in there that might be improved, and if he cared to go into the matter and would telephone me I would go to see him and go over it with him. That brought an immediate response. I took the late train and was met at Altoona by the gentleman I had seen before and taken to the eastern end of the town where their plant was situated. On the way over he told me his partner would be there and a man who was going to be superintendent. When we got there we went into a little office just about large enough for a desk and two chairs, and found these other two gentlemen. I immediately became the center of such a lot of questions that it became embarrassing. I turned to the gentlemen and said, "Before I say anything on this matter I would like to know who this man is whose name is down at the corner as architect. Any criticism I want to make of his plans should be made in his presence rather than his absence." They replied, "Oh, he is only a carpenter around town we got to make those plans. You can say anything you please about them." That cleared the sky and I started in on those three gentlemen. About half past ten I began to run out of matters to talk about and I was wondering whether I was going to get the job. They had not said a word about price. Finally I brought the discussion to a close by saying that was about all the comment I had to make on the design, and the price would be so much. One gentlemen said, "Is that your best price?" I assured him that it was. Then he turned to his partner and said, "Bill, it is nearly eleven o'clock. I think this fellow knows his business. Suppose we give him the job." The deal was closed inside of three minutes thereafter. I speak of this not as a personal exploit but backing up exactly what Mr. Crockett said to-night in regard to the desirability of the salesman knowing his goods and knowing his business.

BOOK REVIEW

By G. LEWIS TAYLOR*

The Economics of Bridgework. By J. A. L. Waddell. xxxii+512 pp., 1921. John Wiley & Sons, Inc., New York. $6.

During the last college year some 48,000 students were pursuing engineering courses in American universities and technical schools. This shows a marvelous growth, when contrasted with the engineering education offered in this country in 1875, when the author was graduated from Rensselaer Polytechnic Institute. The great increase indicates the enormous development of construction work, and mechanical and electrical enterprise.

"The Economics of Bridgework," just published, and announced by Doctor Waddell to be his final work, makes an appeal to a wide class of readers, but when his "De Pontibus" was issued, in 1898, the number of bridge engineers in this country was small indeed, compared with the members of the profession at the present time.

During this period, vast progress in the construction of bridges has been made by American engineers, fully in keeping with the increase in magnitude of the operations, and in the development of the science of bridge construction in this time of its great development. Doctor Waddell has ever been a leader and has held before the profession—and especially its younger members—a name of broad scientific attainment.

It is the experience of almost all, that after graduation a period of some length must be passed, during which, by hard and steady work of routine and ordinary character, there is laid a foundation and knowledge of actual things which, later, can support a successful and fruitful career. If this period cannot be survived, a trustworthy engineer will not be produced; nor, if it cannot be passed through and left behind by advancement to affairs of broader importance, will an engineer ascend to any particular eminence in his profession. Labor leads to advancement, only if done intelligently and with the fullest knowledge of the reasons for each step. It is difficult for executives, in the press of modern business conditions—and even for practising engineers—to explain in detail to their assistants the reason for all their plans and methods, and, if their helpers desire advancement in the science as well as the art of bridgework, each must for himself with all the aids at his command, endeavor to ascertain the full reasons for all that is done.

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None of the leading engineers of the present time has placed the results of his experience at the service of the younger members of the profession to such an extent as the author, and his experience has covered such a wide field in bridge engineering that none of the younger members of his profession can well afford to neglect to partake of the fund of information and the effective guidance which is spread before him in Doctor Waddell's books.

The literature of structural engineering consists very largely of works pertaining to the calculation of stresses and the designing of members and details. Exclusive study of such books, and the ordinary work of every day, are prone to develop only a narrow outlook, and have given rise to the claim that engineers as a class are of narrow vision, and it has even been stated that they are qualified only to determine "how" and not "what" or "where" to build.

Doctor Waddell's books, and in particular his "Bridge Engineering" and his latest work, "The Economics of Bridgework," are written in the spirit of leadership which engineers must acquire to assume their proper place in important affairs.

"The Economics of Bridgework," while announced by the author as his last contribution, is fresh and forward looking—full of suggestions for plans for structures surpassing in magnitude any yet constructed, and for movable bridges, ferry bridges, and other structures differing at least in fullness of development from existing types; and with but four years lacking to complete the author's half century of engineering practice, his latest work shows him as keen for the future as on his graduation day. His unwillingness to rest on his achievements should be an inspiration to younger men.

The book serves two good ends: It is, for the inexperienced, an introduction to practically all of the various fields of the profession of bridge engineering; and, to the experienced, it offers a systematization of the knowledge involved and a collection of all the features comprised in the economic construction of new projects.

Even if engaged in daily work of some particular character, it nearly always happens that one becomes so engrossed in certain features, that important considerations will be overlooked. It is like receiving personal advice on the kind of work under contemplation when considering some particular project, to read over the chapters on such subjects, and Doctor Waddell's new work is broad enough to cover almost every case likely to come up.

Throughout the book will be found many particular points which have occurred in the author's long experience, and, of the two ways of acquiring such particular knowledge, it is much more satisfactory to benefit by another's hard-earned knowledge, than to go through each experience personally, and often by making errors—slowly and expensively corrected—to obtain the absolutely necessary knowledge needed in the engineering profession.

Under the conditions of the present time, most engineers get nearly all their experience in some special division of bridgework, but the author gives an intelligent view of almost every phase of the various kinds of work which are required before any structure can be complete. He leads from the promotion of the project through the minute planning to actual fabrication, inspection, and erection.

Could every engineer who is placed in charge of important structures, have such a broad view and personal knowledge of the problems of each department which would be called upon to render service, and not merely a scientific knowledge of the principles of scientific design, it is certain that fewer difficulties would arise to be slowly and expensively overcome, and large projects would gain materially in speed of execution.

Doctor Waddell has interested himself, as is well known, in the development of alloy steel for large structures, and in the chapter devoted to "Economics of Alloy Steels," a very clear statement is given of the results of his investigations, which will enable the designer in future to determine immediately whether consideration should be given to the use of such material, and assist him in a long step forward in the investigation leading to the definite design for any particular case.

The chapter devoted to "Comparative Economics of High-Level and Low-Level Crossings," especially when considered together with the discussion of "transbordeurs" or ferry bridges, discusses a subject which has had little consideration up to the present time but which will no doubt in future become of increasing importance.

The chapter on "Comparative Economics of Bridges and Tunnels" is timely in view of projected crossings in several cities where either might be considered. It might be well to note, however, that the discussion, being general, naturally cannot consider specific difficulties which are sure to occur, and which are peculiar to each separate project. The necessity of overcoming such difficulties invariably leads to increased cost and is likely to have an important bearing upon the economics of the selection. As an example, future effect of the complete structure on property values in the vicinity should properly be given consideration, and it is quite proper to build a more expensive structure if it will lead to future development and increase assessable value of real estate. Furthermore, it would not be proper to build a structure which would tend to confine the important districts of any city to existing limits, but it is desirable rather so to locate and design any structure that in future years, after expected growth has taken place, the structure will then serve the best interests of the enlarged community.

In view of several most important projects now under consideration, great interest attaches to the chapter covering "Comparative Economics of Cantilever and Suspension Bridges;" and, while the author's conclusions are based on deep study and much investigation, they deal largely with structures of spans much greater than have been constructed.

The Quebec cantilever of 1800-foot span, and the Delaware River bridge under contemplation with a suspension span of 1750 feet, are the largest bridges concerning which authoritative statements may be made as to weight of metal and actual cost, and, while much may be learned from the author's data made from computations for unbuilt structures, final conclusions can be reached only when more is known concerning actual bridges. To illustrate the meaning of this statement, one may consider the great difficulties which had to be overcome in the construction of the Quebec cantilever, and it would appear that for this span practical limits of the sizes of members and erection equipment, based on the present capacity of mills and shops, had very nearly been attained, and, while no doubt these limits will constantly be increased, it can readily be seen that it is exceedingly difficult to say at what expense such results will be achieved. It would appear that difficulties of this nature would militate much more against the cantilever type of bridge on account of the great increase in the size of members required for long spans. The suspension type seems more capable of subdivision as it does not greatly increase the cost of wire cables to use a greater number, nor of eye-bar chains to arrange these in more than one strand, and, as the stiffening trusses are not nearly comparable in section with the main carriers, there is yet a long margin before the size of their individual members and details will give greater trouble in construction; also, there are yet great possibilities to be worked out in utilizing eye-bar chains as parts of the stiffening trusses.

The subject of erection of long-span bridges is so important that it is somewhat to be regretted that the chapter on this subject is rather a summary of existing methods than, like the rest of the book, an effort to draw conclusions which may be useful in the advancement of the art of bridge construction. While fully realizing the difficulties required in such an effort, it may safely be said that the designing of the great bridges in the future will be much more a function of the erection, than, as the author states, the erection to be a function of the design. The methods listed in this chapter are fairly well known to specialists in the erection of steel bridges, and it seems evident that when the requirements of the great structures yet to be built must be solved, the methods of handling erection must be improved, just as the art of fabrication has been advanced, and the possibility of constructing structures of such magnitude will depend upon the success attained.

The appliances and methods used in the Quebec bridge probably represent the highest development up to the present time, and a study of this work and of the rather unusual procedure used in connection with the Ohio River bridge at Sciotoville, may form a starting point for future improvements. It may safely be said that in no department of bridge construction is there a greater demand for high engineering skill and unusual inventiveness.

The work contains "a chronologically arranged list of the author's various investigations and writings on the subject of bridge economics," pp. 489-490.

After reading the book, no engineer can fail to realize the magnitude of the possibilities of future development of bridgework and to appreciate the value of the contribution made by Doctor Waddell's latest work.

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Description of Mather Collieries Plant	*J. R. Elliott*

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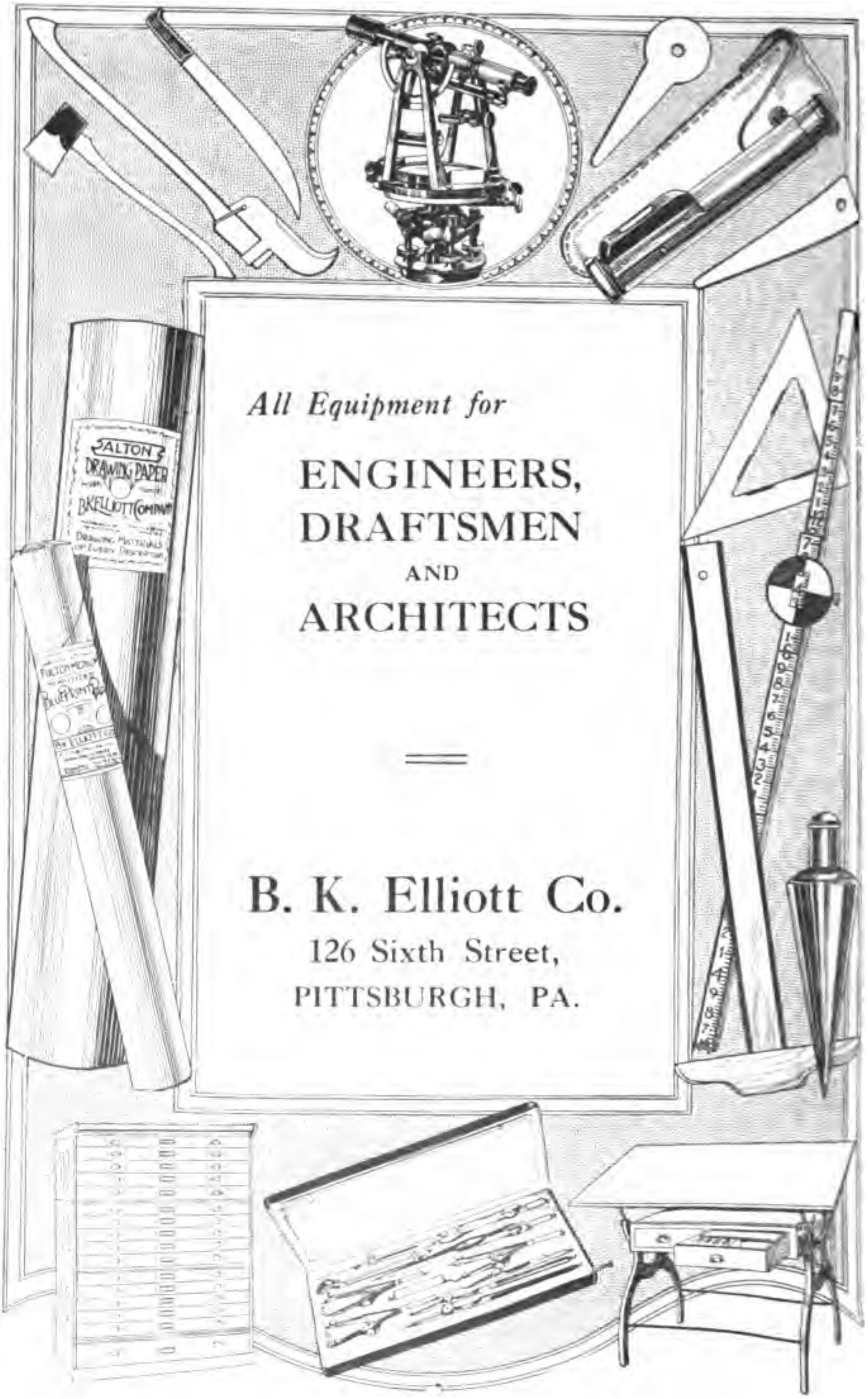

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ERECTION OF STEEL STRUCTURES BY ARC WELDING*

By H. L. Unland†

Electric arc welding of the structural steel framework in building construction presents no serious difficulties that have not already been encountered in the application of this process. The material to be welded has the same characteristics as that used in steel ship construction. Commercial welders in the principal harbors of the country have welded this material without difficulty for a number of years in making repairs to portions of the structure of steel ships.

In 1918 the value of electric arc welding in ship construction was realized in this country and in England. The Marine Classification Societies agreed on a long list of the minor parts of a ship where welding was permitted but the subject was left open by a foot-note to the effect that welding of parts of the ship, other than those listed, should be referred to the Classification Society for approval of each individual case. The United States Shipping Board laid out an extensive program for the application of arc welding to ship-building. This included the training of welders as well as the design work necessary to adapt ship construction to the minor application of welding. Also, designs of ships were made up in which welding only was to be used in the fabrication. This necessitated the building of special shipyards for which the plans were completed when the war ended. Due to the lull in ship-building, the development was not carried further but the decision to start it was made after thorough investigation and trial.

The methods used for structural steel welding will be similar to those used in marine construction since the construction consists of joining structural steel shapes and plates into one rigid structure. The principal drawback to the application of welding in building construction, just as it was in ship-building, is that it has never been done. Within the past three or four years many thousands of tests have been made to show the characteristics of electric arc welds but the tensile tests have, in practically all cases, been based on a straight butt-weld of two plates. This type of weld does not lend itself to structural steel work nearly so well as a fillet-type lap-weld. On this type of weld, however, there is very little actual information as to results of tensile tests. In the straight butt-weld, the stress lies practically in line with the weld but, in the case of a lap-weld, there is a bending stress which throws the plates out of line and causes a tearing action to occur. It is well known that if a tearing stress can be applied to a weld, the strength of the weld will be lower than in case a straight tensile stress can be applied. Deposited metal is found to be satisfactory where it is to be used in compression, the average strength of the metal being 40,000 to 50,000 pounds per square inch in either tension or compression. The results of the few tests of lap-welded samples of which record could be found showed that a double lap-weld would, in many cases, break outside the weld, showing that the joint was stronger than the original plate. Of course, these tests were part of the series made by and for the United States Shipping Board, consequently the work was all done by skilled operators after preliminary practice on similar plates. This latter point is of considerable importance as the change from light to heavy work or from butt-welds to fillet welds, etc., involves a change in the current and sometimes in the electrode size as well as the manipulation of the electrode. Reports of tests made by Lloyd's Register of Shipping were given in the December 1918 issue of the *General Electric Review.** These tests showed that a lap-weld with a full fillet at each edge averaged from 70 to 80 per cent. of the strength of the plate which was about 60,000 pounds. A triple-riveted lap-joint was stated to have an efficiency of 65 per cent. These tests indicate that, in the case of the lap-welded joint, the strength of the joint would be greater than that of a riveted joint if the weld had a total length equal to twice the width of the plate. In all cases the weld formed a full fillet the entire thickness of the plate.

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*Read in absence of the author, by Mr. J. R. Buchanan, Local Engineer, General Electric Co., Pittsburgh.

†Power and Mining Department, General Electric Co., Schenectady, N. Y.

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* v. 21, pp. 864-870.

In order to check these figures, a number of samples were made up as indicated in Fig. 1 and 2. An average operator was instructed to make three lap-welds of 1½ by ¼-inch iron strips.

Fig. 1. Sample Welds.

A 1½-inch angle was assumed to have twice the length of cross-section of the 1½-inch strip, or that it was equivalent to a strip 3 inches by ¼-inch. On the basis that the weld would be twice

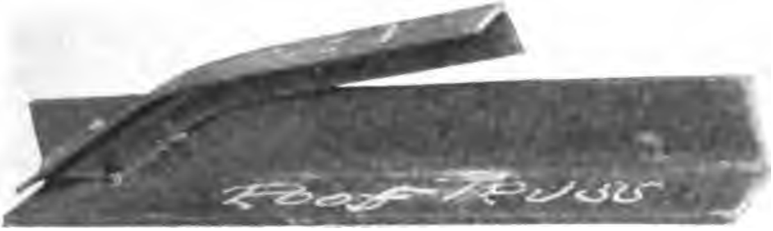

Fig. 2. Sample Weld.

the section width, there would be required six inches of weld in the case of the angle-iron. This was obtained by lapping the angle-iron over the edge of a 2⅞ by ⅜-inch bar, and depositing three inches of weld on each side of the angle-iron. In order to determine the effect of bending stress, a 1½-inch angle-iron, 19 inches long, was welded to a three-inch angle, 24 inches long, to provide a two-in-one pitch representing the ordinary roof slope. This was placed in a testing machine and pressure applied to close the angle. The results of these tests are as follows:

Lap-weld two pieces, ¼ by 1½-inch.

Yield-point		Failure	
Lbs.	Lbs. per sq. in. (Based on section of strap)	Lbs.	Lbs. per sq. in.
16,590	44,000	24,350	64,800
15,100	35,000	19,370	51,000
16,670	44,500	23,060	61,500

In one case the strap broke outside the weld, but the other two broke in the weld by tearing, when the straps bent under the tension. Inspection of the welds showed that the current used had been too low and that the penetration and adhesion were not satisfactory. In spite of this, the poorer joint had 80 per cent. of the strength of the plate.

Lap-weld 1½ by 1½ by ¼-inch angle to 2⅞ by ⅜-inch strap.

Yield-point		Failure	
Lbs.	Lbs. per sq. in. (Area of angle, 0.69 sq. in.)	Lbs.	Lbs. per sq. in.
19,350	28,000	31,700	46,000
15,310	22,200	32,450	47,000
17,770	25,800	32,980	47,500

In all cases the welds gave way, but only after the angle-iron and strap had been deformed to such an extent as to subject the weld to a tearing action. It will be noted that the breaking strength was almost twice the yield-point of the angle, which was considerably deformed, as shown in the illustration. The test of the two angles welded together, in which the weld was subjected to a bending force, showed that in this sample, the weld, even when placed in a position where eccentric loading took place, was stiffer than the angle-iron since the 1½-inch angle passed the yield-point and was merely deformed without greatly increasing the force required. The yield-point was passed at a force of 890 pounds applied to the end of the 1½-inch angle and in a direction perpendicular to the three-inch angle, thus giving a component at right angles to the 1½-inch angle of 796 pounds. These tests indicate that, in order to obtain the greatest strength, it is necessary to design the joints so as to eliminate tearing action on the weld. In the case of the samples tested, this could be accomplished by placing an additional length of weld joining the smaller angle-iron or structural section to the larger one, and locating this weld at the point where the stress tends to separate the two pieces. In the samples shown, this would be across the end of the strap back of the angle-iron, and in the case of the two angle-irons would be along the top of the three-inch angle. This procedure would not only increase actual length of the weld but would place it at a point where the benefit would be the greatest.

If this proceeding were followed, there is little doubt but that practically all joints would break outside the weld. The welds tested were proportional on the following basis. The length of a lap-weld is twice the section length of the smallest section to be joined. A 1½-inch strap of iron would require two 1½-inch welds. A 1½-inch angle section would require two welds, each three inches long, or a total of six inches, for the angle-iron would have a section length of twice 1½ inches, or a total of three inches. Based on a tensile strength of 60,000 pounds, these tests had an efficiency of 78 per cent. A ½-inch rivet in this joint would reduce the section of the small angle to 80.5 per cent. which would be the maximum strength of the joint obtainable with ½-inch rivets. It can be seen from the figures that the load at which failure occurred was approaching the value of twice the yield-point. In other words, the small angle-iron was badly strained and was probably approaching the breaking point. It is very difficult to clamp an angle-iron in the jaws of a testing machine, so it was impossible to obtain the strength of the angle. These tests indicate that the lap-weld should have a length of twice the section length of the smaller section, with an additional weld of half the section length so placed as to prevent tearing apart of the two pieces. This figure applies to sections in which the smaller section is ½ inch thick, or less. If the section increases in thickness above this value, the factor should be increased to three for thicknesses of ¾ inch. This is on account of the increasing difficulty in obtaining thorough fusion as the thickness of the plates increases.

For various thicknesses of section, the speed of making a fillet weld will be approximately as shown in the following table:

Thickness of section	Amperes	Kilowatts	Inches per minute	Electrode pounds per inch of weld
⅛ inch	85	5.1	3.5	0.005
3/16 "	100	6	3	0.01
¼ "	125	7.5	2.5	0.02
⅜ "	150	9	2.2	0.04
½ "	180	10.8	0.75	0.07

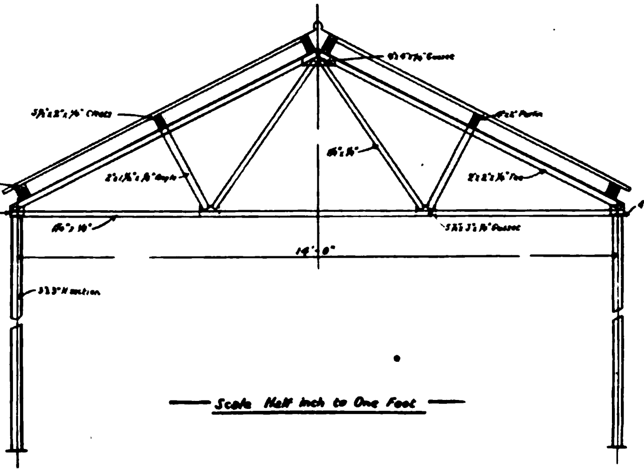

Fig. 3. End Elevation, Welded Steel-Frame Shed.

To show that the subject is not merely of academic interest, at least one company in England (Welded Construction, Ltd.) is putting this process into practice commercially. The first commercial structure entirely welded was a steel-frame shed used as stables for the Olympia Horse Show, in 1920 (Fig 3). This building covered ground space of 9000 square feet with a width of 14 feet. The construction, of course, was very light, but by the use of a simple gig, two welders and four helpers completed ten trusses per day. The structural pieces were cut to length and shipped to the site where the trusses were welded. Caps and base-plates were welded to the columns on which the trusses were later placed and welded. It will be noted that gusset-plates were used at a number of points in order to obtain the necessary length of lap. Using the basis given above for estimating the amount of welding, such a truss would require about 143 inches of weld, which would take approximately one hour. The remaining time would probably be taken up in checking and locating the various members of the jig. The next step was the construction of a saw-tooth roof (Fig. 4). In this case the truss was much simpler, although the members were of heavier section and the span was greater. In these trusses, gusset-plates were unnecessary. In this building the steelwork is all welded. The procedure in construction is as follows:

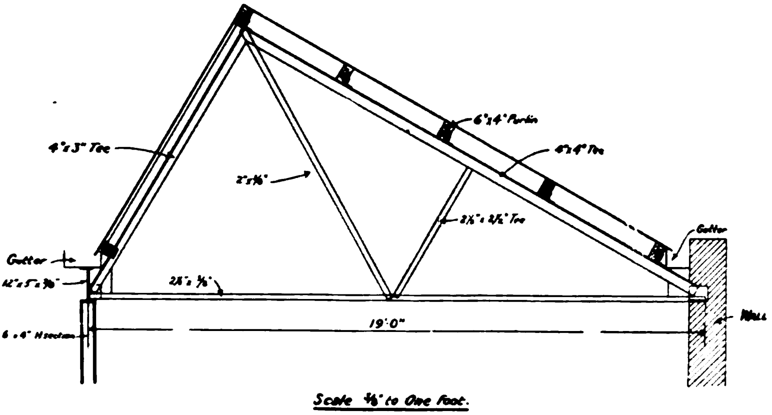

Fig. 4. Construction of Saw-Tooth Roof.

Columns are cut to length, and caps and base-plates welded on at the site, after which they are set up. The joists are hoisted into place on the column cap plates, and welded, being held in place by clamps. The trusses are constructed on the site, since the members are cut to length on the job, and by the use of a simple steel fixture the members are properly located, after which they are welded. The trusses are hoisted into position and welded. The cost figures given on this installation are as follows:

Labor	Welder at 2s. 6d. (60 cents) per hour	6s. 3d.	$1.54
Material	Electrodes	2s. 10d.	0.68
Power	at 2d. per B. t. u	3d.	0.06
		9s.4d.	$2.28

One welder and one helper, after the material is cut to length, average 1½ hours per truss, although they have completed the welding in 50 minutes. The attaching of the caps and base-plates to the columns requires approximately one-half hour. Welding a truss in place requires one-half hour. Based on English practice, the erection of this building showed a reduction of 50 per cent. in the erection cost.

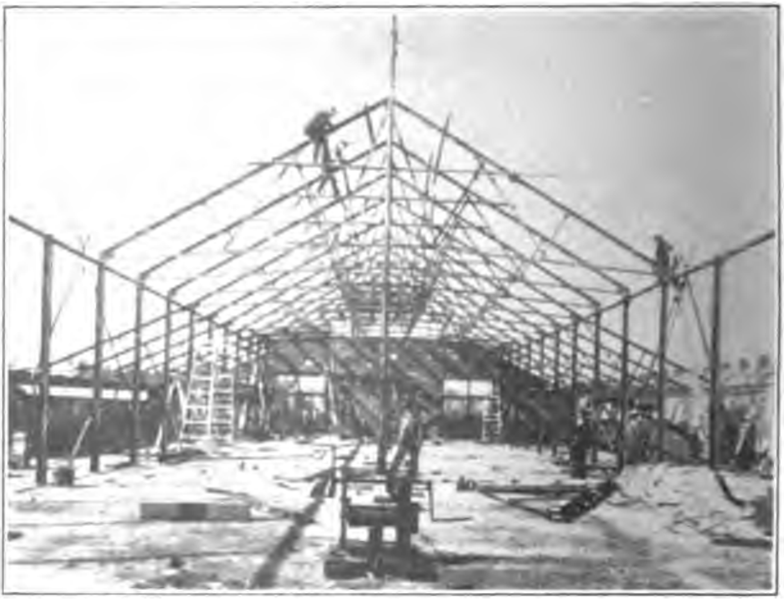

Fig. 5. Machine-Shop Erected by Welding.

A more ambitious contract covered a machine-shop having a central bay 40 feet wide, and wing bays 15 feet wide (Fig. 5-6). The methods used in the construction of this building differed somewhat from those previously described. The columns were prepared at the plant of the welding contractor. After the foundations were completed, these columns were shipped and erected and the joists placed and welded on top of the columns. The trusses were constructed in halves at the contractor's plant, these sections being shipped to the site, erected, and finally welded in place. In welding these trusses, the steel locating fixture was again used. It was unnecessary in this construction to use gusset-plates. The attachment of the compression members alternately on the two sides of the tension members will also be noticed from the illustration. No rivets or bolts were used in any of the work on the structure.

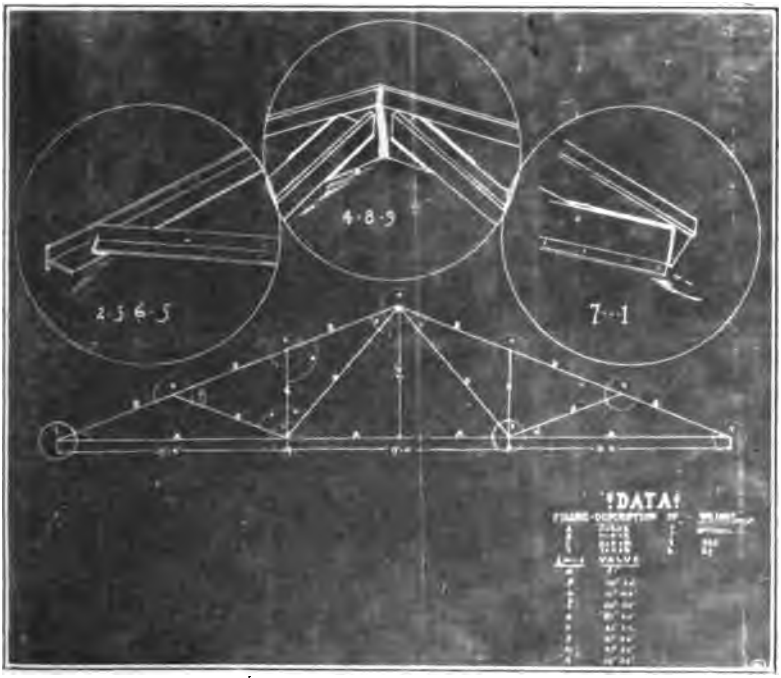

Fig. 6. Details of Electric Welding.

In this country, only one serious attempt has been made to use arc welding in building construction. This structure was a material shed welded as an experiment by the Electric Welding Company of America, at Brooklyn (Fig. 7-12). This structure was tested by the Bureau of Buildings of the City of New York.

This structure was intended to carry very heavy loads, and, from the illustrations showing the welded joints, entire success would be expected. Very little information is available as to the cost of completing this structure, but the designer and constructor, Mr. H. B. Payne, is certain that, with the experience gained on this structure, similar structures could be erected at a cost much lower than if riveting construction were used. While it is probable that with proper design and under competent supervision, skilled welders could successfully put out welded structures of any size, we must remember that there is little experience as to the design of the joints most suitable for replacing riveted joints. Slow progress in making this change is greatly to be desired. Experience with smaller structures will furnish a safe guide in trying out the larger ones.

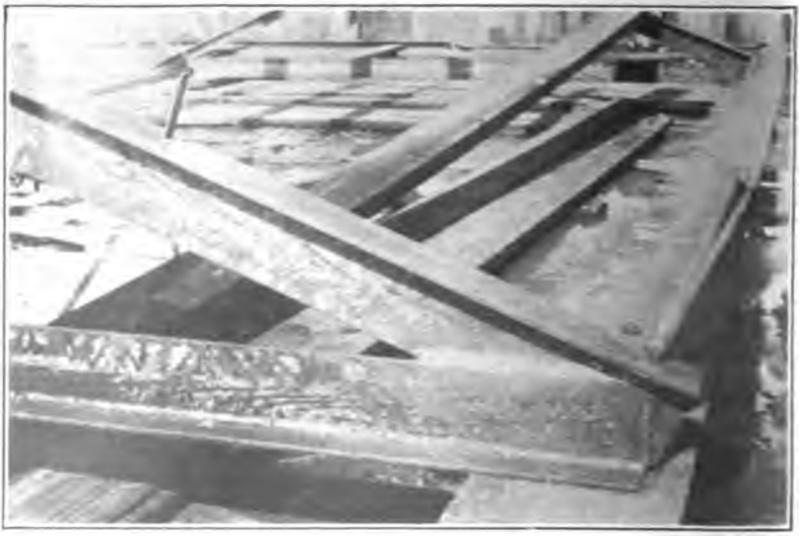
Fig. 7. Method of Welding Eaves.

One point that should not be overlooked in the comparison of the equipment required for welding as against riveting, is that

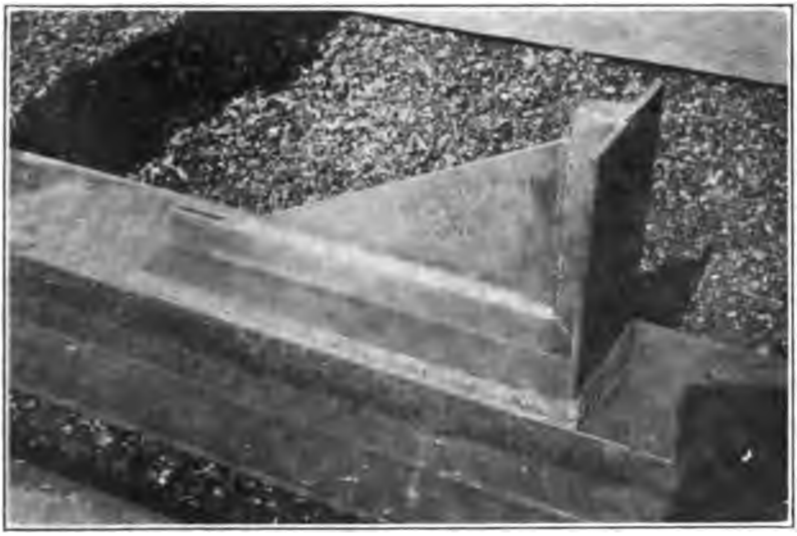

Fig. 8. Bracket Welded to Column.

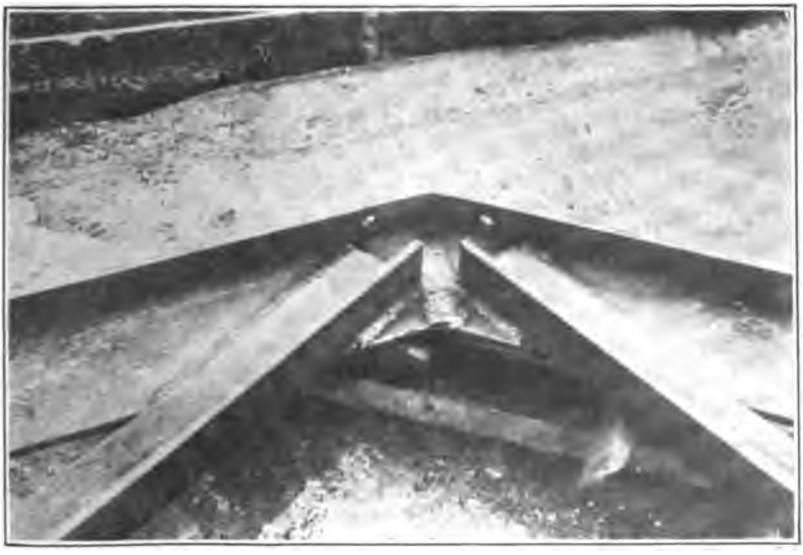

Fig. 9. Method of Welding Roof Truss.

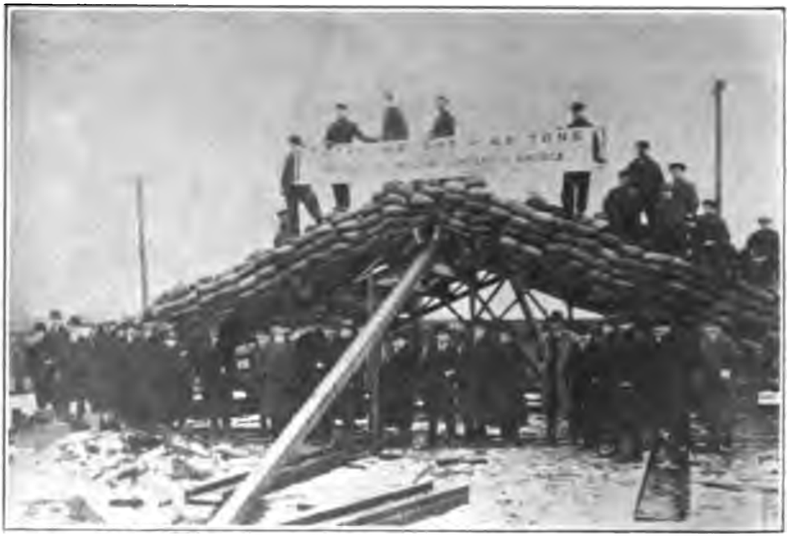

Fig. 12. Testing Electrically Welded Truss.

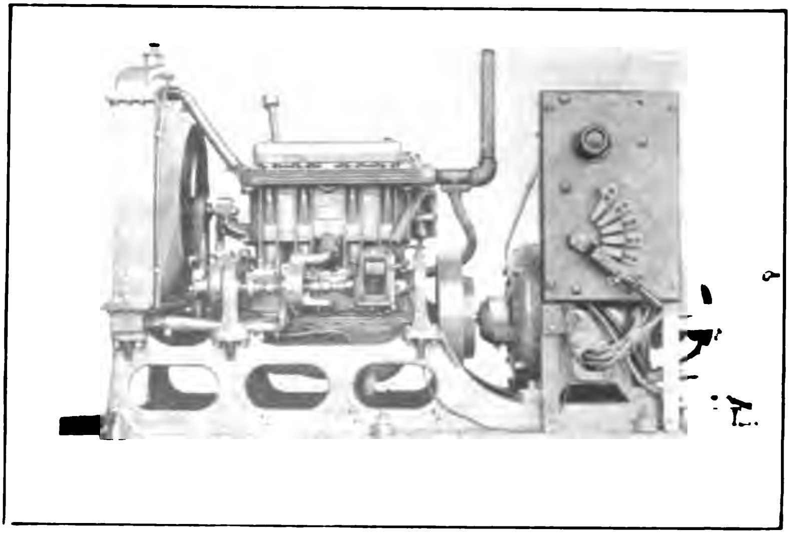

Fig. 13. Arc-Welding Generator Driven by Gasoline Engine.

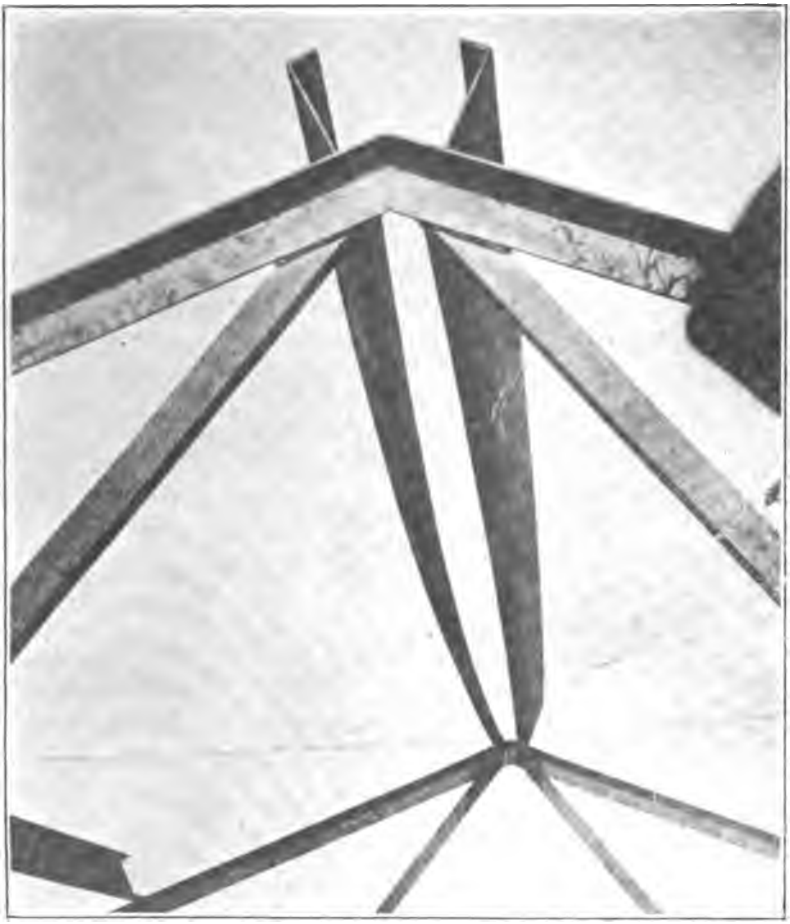

Fig. 11. Roof Trusses in Position.

gasoline engine is shown in Fig. 13. Such an equipment may be carried from one job to another or may be easily mounted on an automobile truck in a semi-permanent manner.

An equipment consisting of a single-operator, arc-welding generator driven by a two-cylinder gasoline or kerosene engine provides a very satisfactory unit for the isolated work. This unit starts on gasoline and changes to kerosene for continuous

DISCUSSION

Mr. E. W. Pittman:* The subject is now open for discussion. It was discussed a great deal in connection with ships during the war and a great deal was published about the experiments the Shipping Board was making. I do not doubt that some of those here are familiar with some of the work done by the Shipping Board. We will be glad to hear from any one who has any discussion to offer or questions to ask.

Mr. Edward Godfrey:† I would like to ask how you get the area of the welds in arriving at the stresses given. Are the welds not made on the edge of the plate? What depth is considered?

Mr. J. R. Buchanan: In all those welds the fillet was the thickness of the plate.

Mr. Edward Godfrey: That is the basis?

Mr. J. R. Buchanan: Yes, that is the basis.

Mr. C. N. Haggart:‡ The paper stated that the cost of erection of welded structures was less than that of riveted structures. To those familiar with steel erection it would seem that a riveted structure would be much easier to erect. In a welded structure it would be necessary to use templets for lining up the parts, and it would take longer to assemble the pieces and hold them in place than where there are holes, which enable one to assemble the structure easily.

Mr. J. R. Buchanan: I do not know that I can answer that question because my experience in practical welding is very limited. At the same time, as stated, these people that have done this welding claim that they can do it in one-half the time. Of course when you have to rivet pieces in the field you have to have a lot of paraphernalia to do it. It is quite an undertaking;

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*President, Pittman-Smith Engineering Co., Pittsburgh.
†Structural Engineer, Robert W. Hunt & Co., Pittsburgh.
‡Architect and Engineer, Pittsburgh.

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so that while I have no definite knowledge on the subject it would seem to me that there might be an advantage in favor of welding even with the possible disadvantage you mention. You have to locate all your holes. They do not always come right. You have to fit your pieces and there must be more fitting done with the riveting than with the welding.

The same attitude was met when it was first proposed to use welding for ship construction. Investigation, however, removed this doubt, and as stated in the paper, at the time the War ended, the United States Shipping Board was proceeding with the plan for using this process in the building of ships.

Mr. C. N. Haggart: With most structural work, there is very little fitting to be done in the field. There is some, but not a great deal. And with a structure such as was shown by the author, the assembling of the finished parts should not take very much time. The welding itself would cost considerably more than the bolting up. Do I understand that the welding is included in the cost of erection or is the welding considered separately?

Mr. J. R. Buchanan: The figures given include all items —welding, labor, fitting, cost of electrodes and cost of power. These figures are based on English practice which may vary considerably from our practice. As stated, there has not been very much of it done in this country. Of course you have to do some fitting with your riveted joint. If you had to do the same amount with the welded joint there would be no advantage.

Mr. F. G. Hagar:* Do these figures refer to the erection only? The elimination of the shop fabrication should be considered also. There would be both punching and riveting to be done in the shop previous to erection and that should be considered in the reduction of cost.

Mr. J. R. Buchanan: I think it is stated that the material was shipped out from the shop and all fabricated in the field, so that would include the whole cost.

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*Draftsman, Keystone Works, Jones & Laughlin Steel Co., Pittsburgh.

Mr. Paul C. Merz:* Is there any record in regard to these joints used in structures sustaining moving loads or alternating stresses, or have you any data covering their efficiency under these conditions?

Mr. J. R. Buchanan: I have no knowledge of such data.

Mr. Edward Godfrey: Of course, we have records when welds are made, as shown by the author's tests of strength and efficiency, but in the field how are we to determine whether the work has been efficiently done? In the case of riveted work we can climb up and tap the rivet and know whether it is tight or not, but I do not see any way in which we can test a weld after it is made, to know whether or not it is efficient in what we call field inspection.

Mr. J. R. Buchanan: An inspection of a good weld shows on the surface that it is a good weld. A poor weld will usually show on the surface. After it is made, a weld cannot be tested for strength except by destruction. However, a skilled supervisor with conscientious welders may be depended upon to do the work satisfactorily. Visual inspection, while a weld is being made, enables the supervisor to judge the quality of the work.

Mr. E. W. Pittman: It seems to me that welding on miscellaneous steel structures, such as mill buildings, involving roof trusses, struts, etc., is always going to be very difficult, and going to make the erection difficult because of the necessary use of a great many templets and frames to space the work properly; but I believe electric welding has a better field in tank work or stand-pipes or structures of that sort where the weld would be continuous and would replace a large number of rivets. If the weld is made only at the rate of two inches a minute, it would not seem that much economy would result from welded connections replacing small riveted connections.

I understand some tests were recently made of welded tanks in the Pittsburgh district, and of riveted tanks of exactly the same shape and section of material, and the welded tanks were very much more efficient than the riveted tanks. Mr. Smith do you have any knowledge of these tests?

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*Consulting Engineer, Youngstown, O.

Mr. H. P. Smith:* The tanks referred to were four feet in diameter and 10 feet long. They were made of ⅜-inch steel plates, and had dished heads of four-foot radius. These tanks were built for experimental purposes. One was riveted and three were arc welded. The tanks were subjected to hydrostatic pressure and the pressure was increased until the leaks equaled the capacity of the hand pump supplying the pressure. The riveted tank withstood 175 pounds pressure; one butt-welded tank 265 pounds pressure; and the other butt-welded tank 465 pounds pressure. A leak in the latter tank around the nipple connecting the hydraulic pump line was welded and the test continued until a pressure of 505 pounds was obtained before the leaks equaled the capacity of the pump. The enormous pressure on the tank distorted the shape of the ends, the heads changing to a somewhat hemispherical shape. None of the tanks failed but pinhole leaks developed at high pressure.

A test of this character shows the strength at the weakest part. The seams in each tank amounted to approximately fifty feet. When we are considering the application of arc welding to structural work the strength of the weakest portion of the weld is of more vital importance than the average strength.

The two arc-welded tanks mentioned were welded by different makes of machines. The proper selection of a machine for welding for structural work is vital to the success of the project. The machine must be automatic, and as nearly fool proof as possible.

Mr. Edward Godfrey: Were these tests of butt-welds?

Mr. H. P. Smith: I see that Mr. Sanford is present and perhaps he can tell us.

Mr. H. S. Sanford:† There were two butt-weld tanks and one lap-weld tank.

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*Secretary, Pittman-Smith Engineering Co., Pittsburgh.
†Acting General Manager, Riter-Conley Co., Pittsburgh.

MR. EDWARD GODFREY: Was that lap-weld a fillet weld?

MR. H. S. SANFORD: Yes, both inside and outside.

MR. E. W. PITTMAN: What is the thickness of the plate?

MR. H. S. SANFORD: [illegible]/16-inch in all cases. The material and design were practically the same in each case. Dished heads were 5/16-inch.

MR. W. B. SPELLMIRE:* Can you give us a comparison as to cost?

MR. H. S. SANFORD: That would hardly be a fair comparison. The fitting up of the tanks cost considerable for welding because the men were used to fitting up for riveting but not for welding.

MR. THOMAS CHESTER:† Was the butt-weld a single or a double weld?

MR. H. S. SANFORD: Riveted on the outside only. The Government will issue a complete report on these tests, later; probably in about two months.

MR. E. W. PITTMAN: Were those tests made for the United States Bureau of Standards?

MR. H. S. SANFORD: They were made by the United States Bureau of Standards.

MR. A. M. CANDY:‡ Along that same line I might cite the case of the York Manufacturing Company, York, Pa. About a year ago they began to investigate the advisability of applying electric arc welding to the manufacture of various parts of their refrigerating equipment, particularly the ammonia receiving tanks. As a preliminary investigation they made four tanks and sent them to four different companies in this country to have each of them

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*Manager, General Electric Co., Pittsburgh.
†District Manager, American Blower Co., Pittsburgh.
‡Welding Engineer, General Engineering Department, Westinghouse Electric & Mfg. Co., East Pittsburgh.

welded and returned to them for testing. Each tank was six feet long and 16 inches in diameter, made of ¼-inch steel plate, with dished heads formed so that a butt-joint was made between the heads and the ends of the tank. The plates were all beveled to 45 degrees and welded, then the tanks were returned to the York Manufacturing Company and they put them through a series of tests. They laid each one on a heavy cast-iron bed-plate with the longitudinal seam uppermost, took a 10-pound weight and dropped it 10 feet at five different points along the seam—at the center, the ends, and two points midway between the center and the ends. This developed no distress in the tanks. Immediately hydraulic pressure of 500 pounds was applied and the tanks showed no leakage or distress. This was followed by air pressure of 350 pounds under water. No leaks developed in any of tanks. After that, each one was tested hydraulically until failure occurred as shown by the following table:

Tank number	Pressure in pounds per square inch when failure occurred	Fiber stress in shell plate in pounds per square inch when failure occurred
1	1400	44,800
2	1500	48,000
3	2200	70,400
4	1350	43,200

The last tank showed excellent welding. The crystalline structure in the deposited metal was very fine and the high stresses set up were indicated very clearly by the marked flaring of the plate at the edge of the break and also by the fact that the break ran down the longitudinal seam into the head seam where the sheet joined the head, and actually broke the head joint for about eight inches along the end of the steel plate. I am sorry I do not have illustrations of these available. They were very remarkable tests. It shows what can be accomplished where all the underlying fundamental principles of arc welding practice are applied.

There is one other point I have in mind. A short time ago I had the opportunity of talking with Mr. H. B. Payne, who was mentioned as having been the erector of this small building in

Brooklyn. Mr. Payne told me he was able to erect that building for about $25 per roof truss, where his nearest competitor for riveted roof truss showed a shop cost for the construction of the trusses of $24. I may have those figures reversed, I am not certain.

While I am on my feet, I wish to take a little more time, as your Secretary sent me a copy of the paper to look over and I read it with a great deal of interest, for several reasons. In the first place I am vitally interested in welding. In the second place, Mr. Unland and I were classmates. In looking over the paper, it struck me that it might be interesting to present some of the data which our research engineers have developed relative to the characteristics of arc-deposited metal. One of the gentlemen brought up a question right along this line when he questioned the ability of arc-deposited metal to withstand alternating or vibratory stresses.

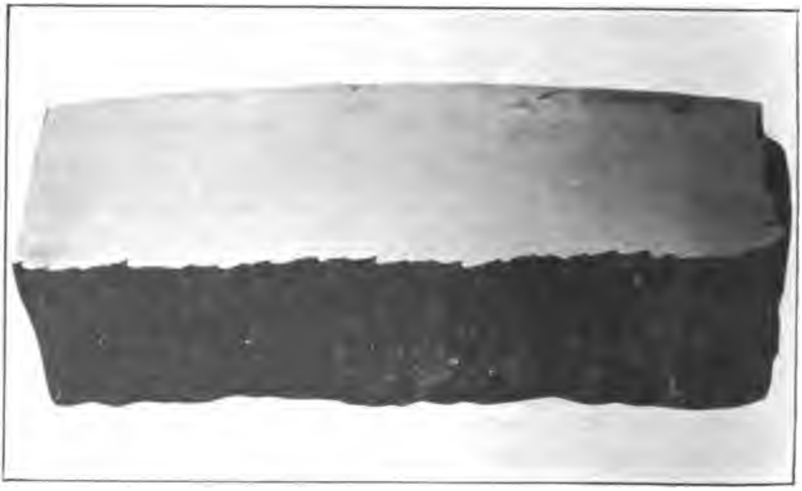

Fig. 15. Section through Arc-Deposited Metal.

To determine the characteristics of arc-deposited metal proper we had an operator build up a large deposit upon several ⅜-inch steel plates as indicated by Fig. 15, which shows a section through a 14-pound deposit. In putting down the various strings of metal, the direction of strings of deposit for alternate layers was reversed. In other words, one layer of metal was put down with the strings of deposit running longitudinally on the plate, whereas the next layer was put down with the strings of metal running laterally across the plate. Samples of this type were made up in two forms—(1) where each layer of metal was merely cleaned off thoroughly with a wire brush, and (2) where each layer of metal was thoroughly sand-blasted so as to remove all slag from the surface of the metal. These blocks of deposit were sufficiently large so that several standard tensile test-pieces and

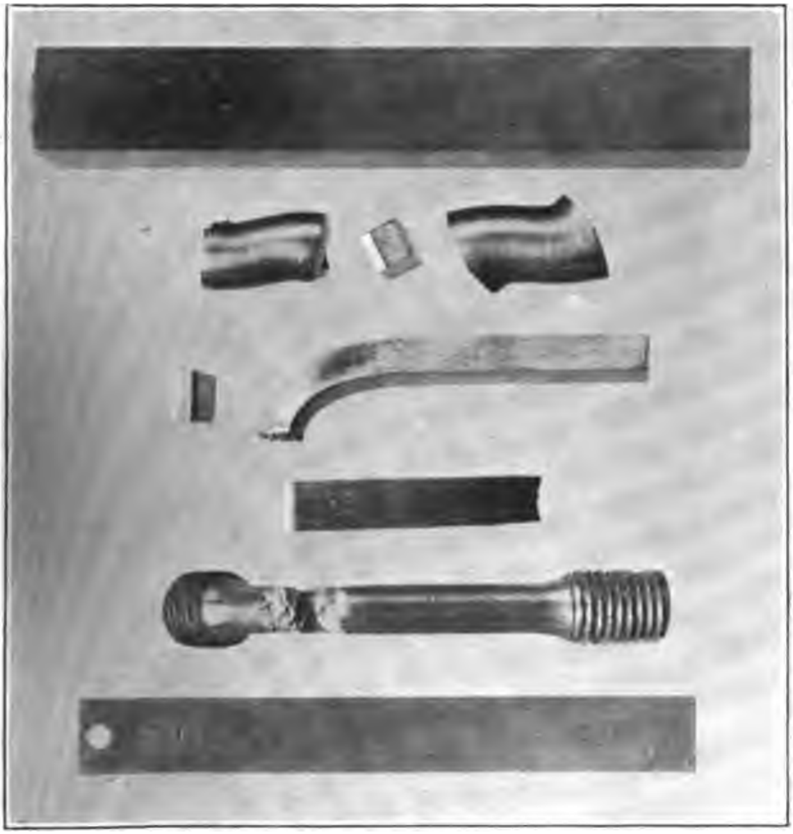

Fig. 16. Tests on Specimens of Arc-Deposited Metal.

other types of test samples could be turned out of the solid arc-deposited metal as indicated by Fig. 16. The comparative results of the tensile tests on the wire-brushed samples and the sand-blasted samples are given in Table I*.

TABLE 1. TENSILE TESTS

		Pounds per square inch			Per cent.	
Layers cleaned by	Test number	Ultimate tensile strength	Yield-point	Elastic limit	Elongation in two inches	Reduction of area
Wire brush	1	58,825	41,000	40,000	8.2	19.9
Wire brush	2	54,650	35,000	29,000	6.5	13.4
Sand-blast	5	56,075	35,875	29,000	16.0	23.4
Sand-blast	6	58,225			18.0	27.8

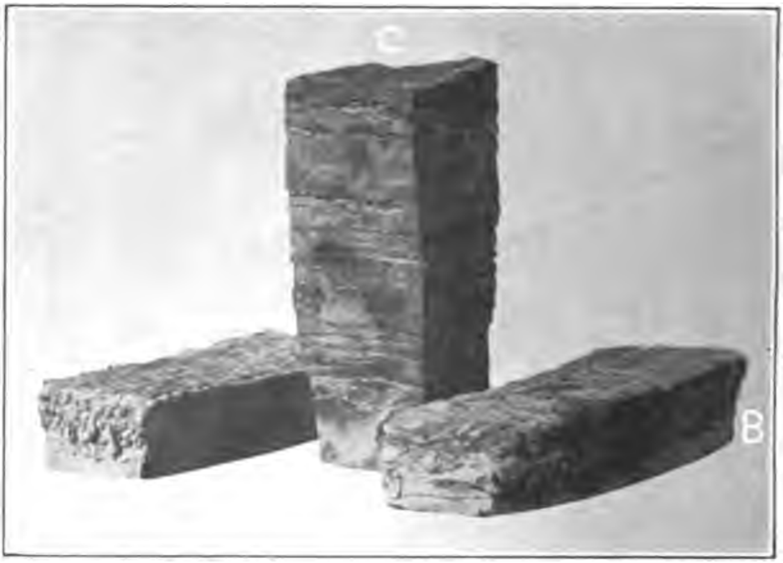

Fig. 17. Samples for Testing Influence of Direction of Metal Deposition.

The fracture had the appearance of high-grade, partially annealed, low-carbon, cast-steel. It is interesting to compare tests 5 and 6 with 1 and 2, and observe that while sand-blasting the layers of metal did not appreciably effect the tensile strength, it did improve the ductility of the metal as evidenced by the increase in the per cent. elongation, and the reduction of area, an average of 100 per cent.

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*Tables I-VIII from Westinghouse Electric & Mfg. Co. "Reprint Bulletin" 96.

To determine the influence of direction of metal deposition on strength of welded joints, three test samples were made up as indicated by Fig. 17, in which (*A*) has the strings of metal placed longitudinally on the plate; (*B*) has the strings of metal laid down laterally across the plate, and (*C*) has the strings of metal built up in layers so that the directions of the strings of metal in the alternate layers are at right angles to each other. In each case the test-pieces were cut out of the metal so that the axes of the test-pieces lay along the major axes of the built-up deposit. It is obvious, therefore, that test-pieces cut from block (*A*) stress the deposited metal along the axes of strings of deposit, whereas those cut from sample (*B*) stress the arc metal at right angles to the direction of the strings of metal, and the test-pieces cut from sample (*C*) stress the metal at right angles to the layers of deposit. The results of the tests on these three specimens are given in Table II.

TABLE II. PROPERTIES OF ARC-DEPOSITED METAL

Metal constituents	C	Mn	S	P	Fe
Analysis of wire electrode, per cent.	0.16	0.56	0.024	0.032	99.2
Analysis of deposited metal, per cent.	0.05	0.19	0.013	0.024	99.7

Tensile strength

Deposit Fig. 17	Pounds per square inch			Per cent.	Per cent.
	Ultimate tensile strength	Yield-point	Elastic limit	Elongation in 2 inches	Reduction of area
A	56,100	33,400	27,500	18.1	30.8
	56,075	35,875	29,000	16.0	23.4
	58,225	....	....	18.0	27.8
B	51,375	29,050	24,000	14.1	18.8
C	40,875	29,400	24,250	4.4	15.9
	43,500	28,900	20,000	4.9	7.0

Compression	Load at 10 per cent. compression lb. per sq. in.	Elastic limit lb. per sq. in.
A	63,250	32,000
B	60,750	30,700
C	60,700	30,400

Cantilever	Ultimate stress, lb. per sq. in., 6-in. arm.
A	64,600
B	63,400
C	61,000

Transverse	Elastic limit, lb. per sq. in. (6 in. between supports)
A	27,850
B	28,000
C	28,500

Shear	Stress at shear, lb. per sq. in.
A	39,200
B	41,450
C	38,500

Impact, Izod	Foot-lb. to fracture standard notched specimen Test 1	Test 2	Test 3
A	1.5	1.5	1.5
B	1.5	1.0	1.5
C	1.0	1.5	1.5

Bending	Distance in inches at fracture
A	0.625
B	1.00
C	1.25

Hardness, Brinell No. 114.

Fig. 18 shows the angle through which the test specimens were bent as given under Table II under the heading of "Bending", A, B, C, corresponding to pieces as lettered in this figure.

Regardless of the fact that numerous tests have demonstrated that the best results can be obtained when arc-deposited metal is put down in series of superimposed strings and layers, it is the common practice for many operators to put down arc-deposited metal in "bulk deposition" wherein the entire space between two plates, for example, is welded as the operator progresses instead of building up the joints by means of series of superimposed strings and layers of metal. To show the relative merits of putting down the metal under these two conditions Tables III and IV are submitted.

TABLE III. PROPERTIES OF ARC-DEPOSITED METAL WHEN LAYERS OR SUPERPOSED TIERS ARE DEPOSITED AT RIGHT ANGLES

Pounds per square inch			Per cent.	Per cent.
Ultimate tensile strength	Yield-point	Elastic limit	elongation in 2 in.	reduction of area
58,825	41,000	34,500	9.2	19.9
54,650	35,000	29,000	6.5	13.4

Compression, elastic limit, pounds per square inch, 29,450 and 34,500.
Hardness, Brinell No. 114.
Shear, 46,200 and 44,600 pounds per square inch.
Bending, 100 degrees on 1 inch radius, bar one-half inch thick.
Impact, Izod, unannealed specimens 2.2 and 1 foot-pounds.

TABLE IV. TENSILE PROPERTIES OF ARC METAL FORMED BY BULK DEPOSITION

Pounds per square inch			Per cent.	Per cent.
Ultimate tensile strength	Yield-point	Elastic limit	elongation in 2 in.	reduction of area
35,375	22,500	19,000	3.6	10.8
31,875	22,000	20,000	3.2	9.3
60*	64*	65*	24*	45*

*Ratio of average results obtained from bulk deposition to average results, A and B, Table II and Table III, from layer deposition, per cent.

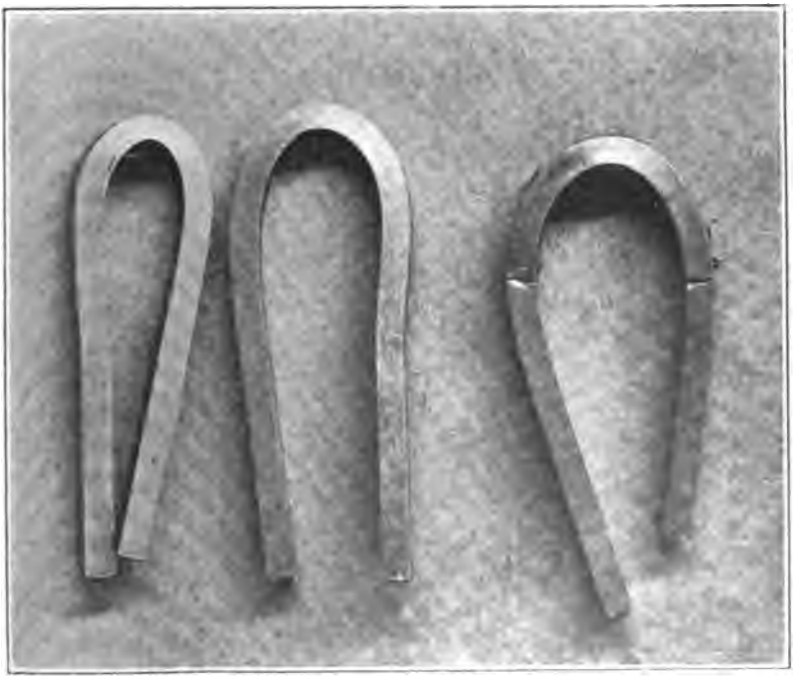

Fig. 18. Results of Bending Test on Arc-Deposited Metal.

When carrying out this experimental work a very interesting phenomenon was discovered—that is, that the strength of an arc-welded joint increases with the strength of the plate material welded, even though the same welding wire is used in every case. The result of these tests, and brief explanation are given in Table V.

TABLE V. INCREASE IN WELD STRENGTH WITH INCREASE IN STRENGTH OF PARENT METAL

Parent metal	Shank metal ultimate tensile strength	Weld ultimate tensile strength
Mild, open-hearth, hot-rolled steel, 0.15 per cent. C	50,000	49,660
Ship plate, 0.30 per cent. C	64,700	62,600
High-carbon steel, 0.85 per cent. C	100,000+	70,000

This table reveals the important fact that arc-deposited metal fused to a stronger shank metal shows characteristics superior to the pure deposited metal. The increase of joint strength may be attributed to (1) absorption by hot cast metal of alloying ingredients present in the parent metal; (2) decreased oxid and nitride content in the region of fusion, due to an increase of arc-enveloping gases caused by the alloying ingredients; (3) improved fusion at scarf surface, due to lower melting point of parent metal; (4) difference in stress distribution.

In Tables VI-VIII, including a short explanation under each, are given the results of the tests made in Europe when making welds using electrodes covered with a certain amount of coating which protects the arc-deposited metal from the air, thereby preventing the formation of so much iron oxid and iron nitride.

In Table VI are shown the results of tests on arc metal obtained from a mild-carbon steel electrode covered chiefly with a mixture of carbon, calcium carbonate, and water glass.

TABLE VI. PROPERTIES OF ARC METAL DEPOSITED FROM COVERED ELECTRODES

Ultimate tensile strength	Elastic limit	Per cent. elongation in 8 in.
61,000	47,800	8.5
58,000	45,600	17.5
51,600	40,000	19.0
52,200	26,000	19.2

The results of a series of rotary bending fatigue tests indicated infinite life at a bending stress of 18,000 pounds per square inch. Similar fatigue tests on welded material indicated infinite life at stress of 24,000 pounds per square inch.

In Tables VII and VIII are given the average results of tests made for Lloyd's Register of Shipping, by David Kirkaldy & Sons, London, on arc-deposited metal and ship-plate welds using asbestos-covered electrodes.

TABLE VII. AVERAGE RESULTS OF TENSILE TESTS ON WELDS AND ARC METAL WHEN USING ASBESTOS-COVERED MILD-STEEL ELECTRODES

Specimen	Pounds per square inch Ultimate tensile strength	Yield-point	Per cent. Elongation in 8 in.	Per cent. Reduction of area	No. of tests
Unwelded	62,000	....	28	45	4
Welded	60,400	....	18	35	8
Arc-deposited metal*	64,500	44,600	13	21	2

*Modulus of elasticity of arc-deposited metal by 27,000,000.
Modulus of elasticity of mild steel 30,000,000.

In Table VIII are given the results of alternating-stress tests on welds made with asbestos-covered electrodes. In these tests the butt-weld in a circular bar was submitted to a continued bending stress in one direction and the bar rotated at a speed of 1000 r. p. m.

TABLE VIII. ALTERNATING-STRESS TEST 1000 R.P.M. ⅝-INCH DIAMETER ROUND BAR, ON WELDS MADE WITH ASBESTOS-COVERED ELECTRODES

Specimen	Stress at periphery Lbs. per sq. in.	Rotations	Remarks
Unwelded	± 23,500	5,000,000	Fractured
Welded	± 14,000	4,355,000	Fractured
Welded	± 14,000	5,000.000	Unbroken
Welded	± 18,800	5,000,000	Unbroken
Welded	± 18,800	1,705,000	Fractured
Welded	± 20,500	1,510,000	Fractured

While an improvement in physical properties can be obtained through the employment of suitably covered electrodes, their proper use requires a high degree of skill to assure consistent fusion and slag removal. The advantages of the covering will perhaps become more pronounced if applied to alloy steels, since the gas envelope obtained will permit the transference of such important constituents as carbon, nickel, chromium, vanadium, etc., in appreciable quantities.

The writer believes that these data will not only prove of interest but will also prove of material assistance to the design engineer and draftsman who expect to apply arc welding for the building of steel structures.

MR. O. H. ESCHHOLZ:* Mr. Unland has chosen a most opportune time for the discussion of arc-welded structures, as the recently completed constructions described are evidence of the successful entrance of arc welding into a new, and perhaps its largest, field.

I am in hearty agreement with the author in respect to the need for additional knowledge on the physical properties of welded joints applicable to such structures To prepare the ground for the development of this information, I have summarized in *Power*, for Feb. 15, 1921,† the physical properties of arc-deposited metal and arc welds.

To be applicable to the subject of this discussion, such information should be supplemented by data on the properties of fillet welds under various conditions of direction and character of strain, depth of arc penetration, number of layers, etc. If data of this nature be compiled on a unit basis, it will permit the approximate calculation of the resistance to stress of welded joints in a manner quite similar to that now employed for riveted joints.

MR. E. R. SPENCER:‡ It would be interesting to get an idea of the comparative results with thin plates and thicker plates.

MR. J. R. BUCHANAN: The unit strength of welds in thick plates is usually lower than in thin plates of similar material.

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*Section Engineer, Material and Process Engineering Department, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

†v. 53, pp. 250-255.

‡Sales Engineer, Thomas Spacing Machine Co., Pittsburgh.

The difficulty seems to lie in getting uniform deposition throughout the depth. This point was referred to in the paper where the factor was increased for plates over ½-inch in thickness. Those who are interested in the subject of arc welding, are referred to bibliographies published in the *General Electric Review** and other publications.

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*v. 21, pp. 653-658.

DESCRIPTION OF MATHER COLLIERIES PLANT

BY J. R. ELLIOTT[*]

LOCATION

The property of the Mather Collieries, consisting of about 4400 acres, is located at Mather, north of the village of Jefferson, Greene County, Pa. The operation is owned jointly by Pickands, Mather & Company; the Cleveland-Cliffs Iron Company; and the Steel Company of Canada, Ltd., Hamilton, Ont., and operated by Pickands, Mather & Company, of Cleveland. The town of Mather is named in honor of Samuel Mather, senior member of the firm of Pickands, Mather & Company, and William G. Mather. of the Cleveland-Cliffs Iron Company. It is served by the Chartiers-Southern Railroad, owned jointly by the Pennsylvania Railroad, the New York Central Railroad, and the Baltimore & Ohio Railroad, connection being made with the Monongahela Division of the Pennsylvania Railroad at Millsboro on the Monongahela River. For location of property see Fig. 1.

The coal is used entirely by the owners in by-product plants located at Toledo, Canton, and Cleveland, Ohio, and Hamilton, Ont., being transported in 70-ton capacity railroad cars owned by the Mather Collieries.

GEOLOGY

The seam mined is the Pittsburgh seam. The Bellevernon anticlinal passes through the property but the shafts and principal part of the field lie on the eastern slope of the anticlinal. The coal dips to the southeast at about an average grade of 1.5 per cent. and the cover over the coal varies from 300 feet at Ten Mile Creek to 650 feet under the highest hills.

The seam of coal as indicated by present development and numerous drill holes at various locations on the property will average six feet, nine inches thick and produce a tonnage of 10,000 tons per acre.

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[*] Baton & Elliott, Engineers, Pittsburgh.

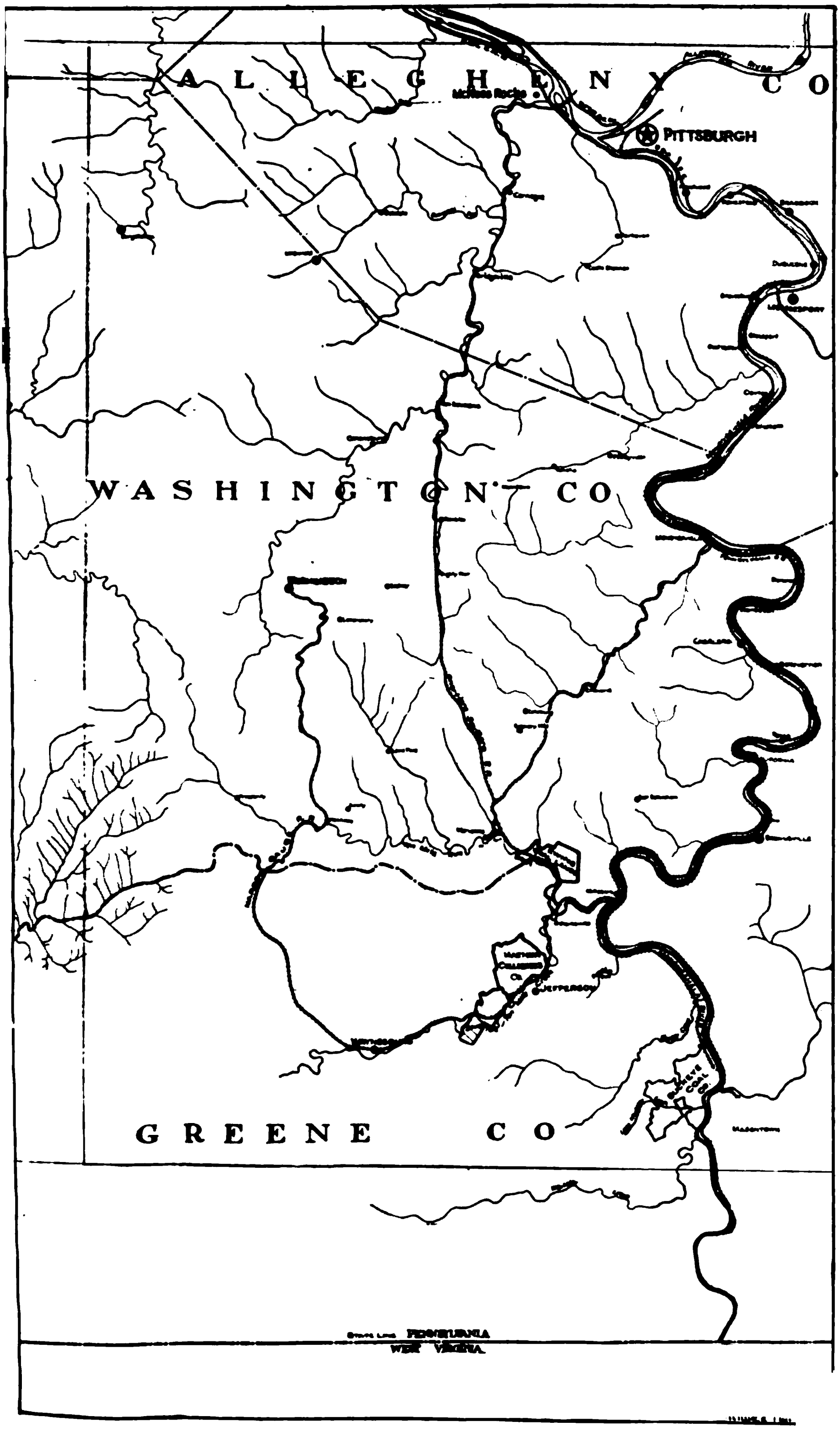

Fig. 1. Location of Mather Collieries.

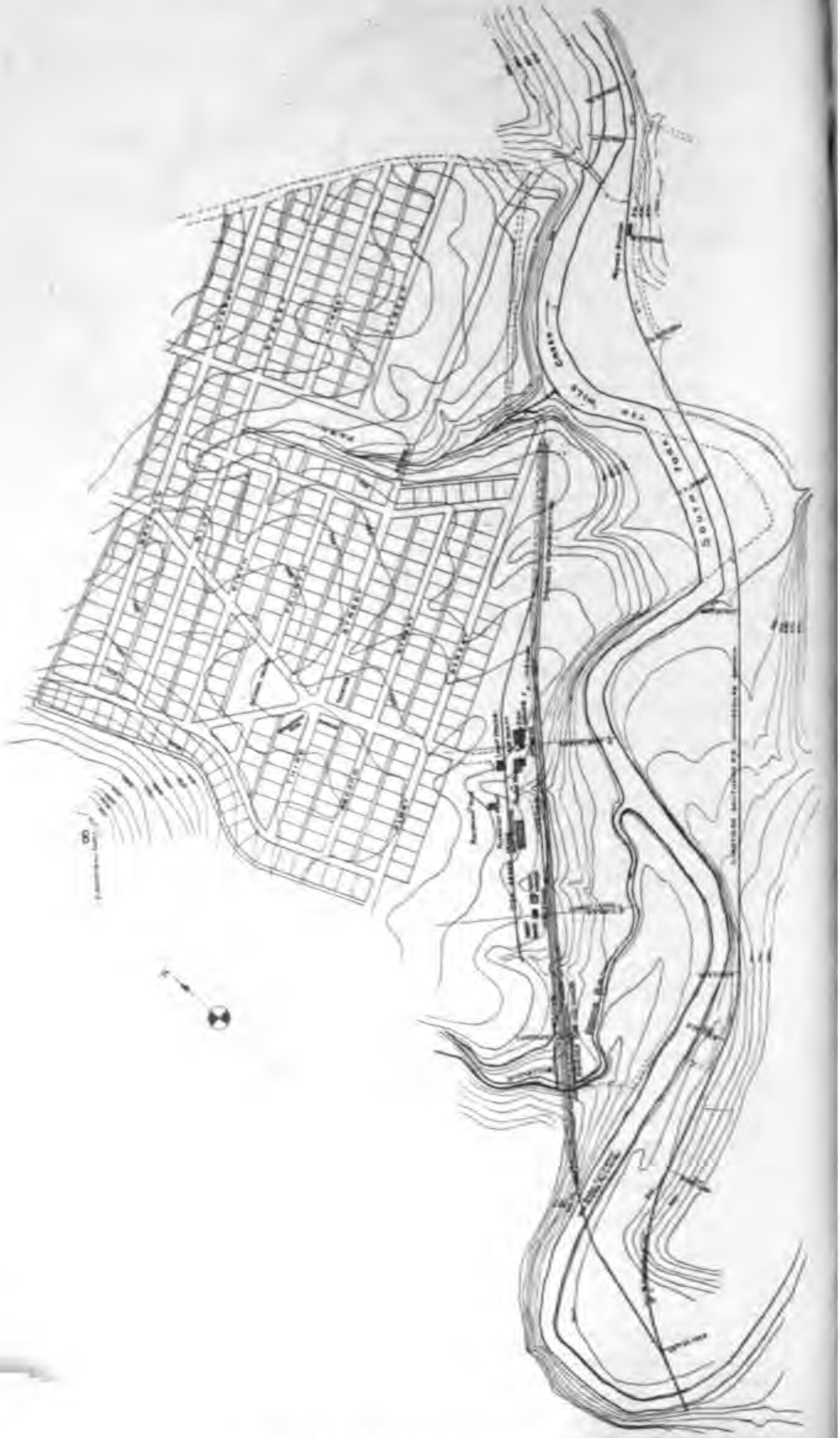

Fig. 2. Plant and Town-Site.

From all data secured we are led to believe that the seam is uniform as to the thickness and cover over the coal. The average analysis for shipments covering the period June to December, 1920, showed:

Moisture	3.0	per cent.
Volatile matter	34.6	" "
Fixed carbon	54.8	" "
Ash	9.16	" "
Sulphur	1.15	" "

TOPOGRAPHICAL CONDITIONS

The topography of the property is typical of southwestern Pennsylvania, being a rolling agricultural country. The south branch of Ten Mile Creek flows along the southeast side of the property at an elevation slightly below 900 feet above sea level, and to the northwest elevations of 1100 to 1200 feet are reached on the property. The general direction of Ten Mile Creek is parallel to the Bellevernon anticlinal and forms the lowest elevation so far as the coal seam on the property is concerned. The creek valley is the only feasible route for a railroad outlet and necessitated that the surface plant and point of development of the property be located contiguous thereto, and a plant location was chosen near the southeast central portion of the tract, so that the haulage would be in favor of the loads.

RAILROAD CONNECTION AND SIDING FACILITIES

The Chartiers-Southern Railroad was located and built on the opposite side of Ten Mile Creek from the plant site. Owing to topographical conditions it was necessary to construct the sidings with one connection with the railroad. This involved the construction of a two-span, deck, plate-girder bridge across the creek and a passing track from the lower end of the yards to a point above the location of the No. 2 shaft. See Fig. 2.

The yard is arranged for the ultimate storage capacity of 100 loads and empties, with ample facilities for switching between the two shafts, so as to avoid interference when it becomes necessary to have the two hoisting shafts in operation. This

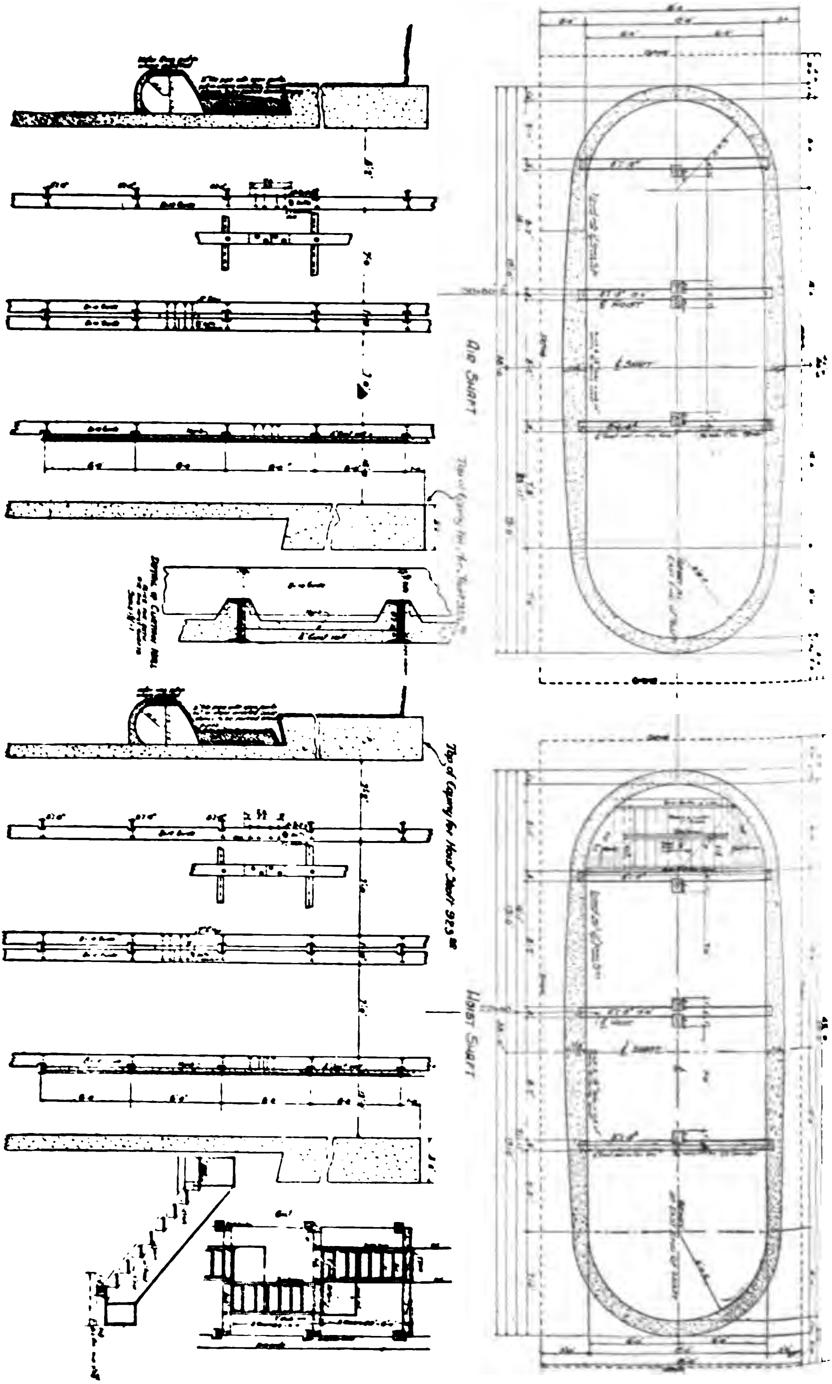

Fig. 3. Details of Concrete Shafts.

feature determined the distance between shafts of 850 feet. It will be noticed that three loading tracks are provided for No. 1 shaft and two for No. 2 shaft. The product shipped is run-of-mine, but provision was made for separating and loading slack in case it should prove advisable.

The sidings are laid with 90-pound rails on standard ties. All turnouts are No. 8. The track is ballasted with granulated slag.

SHAFTS

Owing to the outline and location of the property it was decided that for the most economical operation it would be wise to consider the tract as two separate operations, but operated with the same surface plant; consequently, both shafts were designed as hoisting shafts—No. 1 to be used exclusively for hoisting coal and slate, and therefore for the larger output, and also to serve as an intake for air. No. 2 to be used for hoisting coal and slate, men, and supplies, and one compartment to serve as an air exhaust. The shafts are the same inside dimensions, the difference in arrangement of buntons being that they are so placed as to give a slightly larger area for exhaust airway in No. 2 and to provide room for stairway in No. 1, if deemed necessary. This stairway has not been constructed at the present writing. See Fig. 3 for details of shafts.

The shafts are concrete lined, with steel buntons and reinforced concrete partition between hoistways and air compartment. From top of coping to bottom of coal, No. 1 is 341 feet in depth and No. 2 is 349 feet.

.Ground was broken August 20, 1917 on No. 1 and August 7, 1917 on No. 2. Coal was reached May 8, 1918 on No. 1 and May 20, 1918 on No. 2.

The time required to sink and line both shafts was approximately nine months—an average rate of 39 feet per month. In normal times this would be considered slow, but, owing to war conditions, shortage of labor, and the work being located some five miles from a railroad, it was up to the average obtained on other work being prosecuted during the same period. No exceptional conditions were encountered, as the shafts were perfectly dry. The material used for concrete was crushed sandstone, an abundance of which was found on the property.

The following is a log of the material in No. 1 shaft:

Material	Thickness ft. in.	Depth ft. in.	Remarks
Clay and sand	10 0	10 0	
Shale	6 0	16 0	
Limey shale	8 0	24 0	
Limestone	5 0	29 0	
Shale	23 0	52 0	
Shaly limestone	11 0	63 0	Breaks up readily in air
Limestone	5 0	68 0	
Shaly limestone	13 6	81 6	
Limestone	1 6	83 0	
Flinty limestone	11 0	94 0	
Limestone	6 0	100 0	
Soft limestone	6 0	106 0	Slacks in two or three days
Dark shale	3 0	109 0	
Limestone	10 0	119 0	Used for concrete
Hard slate	2 0	121 0	
Shaly limestone	6 0	127 0	Too soft for use
Limestone	15 0	142 0	Used for concrete
Dark shale	9 0	151 0	
Limestone	23 0	174 0	Part of this unfit for use
Limestone (dark streaks)	25 0	199 0	
Dark shale	11 0	210 0	
Bony coal	1 1	211 1	
Dark sandy limestone	25 0	236 1	
Light sandy limestone	8 0	244 1	
Dark shale	12 0	256 1	
Sandstone	6 0	262 1	Used for concrete
Sandy limestone	21 0	283 1	
Soft dark shale	3 0	286 1	
Soft limestone	6 0	292 1	
Dark shale	6 0	298 1	
Dark sandy slate	24 4	322 5	
Coal	1 4	323 9	Measured on empty car side of shaft
Slate	0 3	324 0	" " "
Slate	0 7	324 7	" " "
Bony coal and slate	1 10	326 5	" " "
Slate	4 9	331 2	" " "
Coal	1 0	332 0	" " "
Slate	0 4	332 4	" " "
Coal	0 9	333 3	" " "
Draw slate over coal	0 8	333 11	" " "
Coal	6 11	340 10	" " "

PLANT BUILDINGS AND SURFACE EQUIPMENT

The surface plant consists of the power-house, shop, hoist house, fan house, lamp house, first-aid building, filtration and pump house, head-frames, and tipple including storage bin. All of the buildings, except the last mentioned, are constructed of brick on concrete foundations with steel trusses. They are roofed with cement tile and are substantially fireproof.

Power-Plant. Power for operating is purchased from the West Penn Power Company. Current is delivered to the plant at 22,000 volts and reduced through transformers to 2200 volts. In fixing the sizes of the various power units to be installed, the following duties were required:

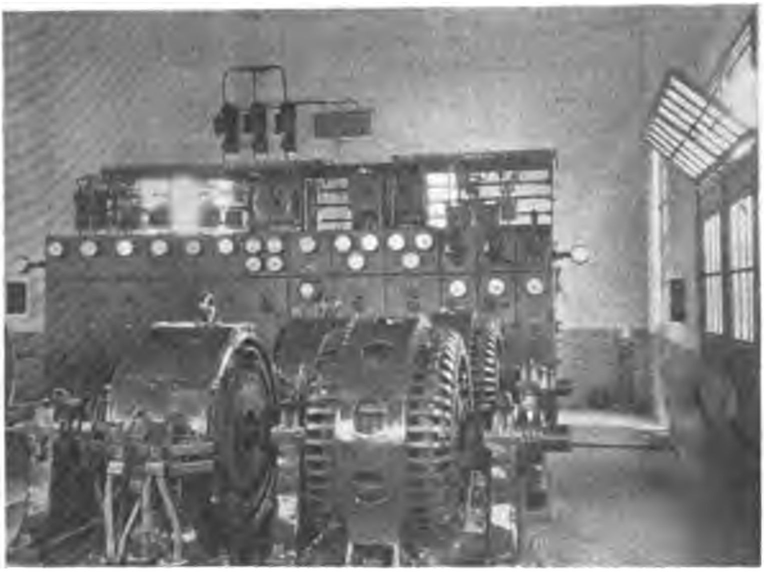

Fig. 4. Motor-Generator Set and Switchboard.

For the main hoist. Three hoists per minute and 2¾ tons of coal per hoist, requiring 1000-horse-power induction motor.

For the man and supply hoist. One and one-fourth hoists per minute of 2¾ tons coal per hoist, requiring 300-horse-power induction motor.

For supplying direct current for haulage, etc. Two 200-kilowatt, 2200-volt, alternating-current, 250-volt, direct-current, synchronous motor-generator sets.

In addition to the above, there were required a 2200-volt motor for the fan, and various small 220-volt motors for running shop and tipple machinery.

The mine being situated in a gaseous region, it was deemed advisable to provide some auxiliary power supply in addition to the service furnished by the power company, to be available if source of supply should be out of service on account of accident to the transmission lines, or other causes. The auxiliary power unit installed is large enough to operate the fan and the man and supply hoist, thus providing for proper ventilation and the hoisting of men from the shaft. It consists of a battery of Babcock-Wilcox boilers of 264 horse-power rated capacity, with feed-water pump and heater and one 250-kilowatt, 2200-volt generator direct connected to an 18 by 22-inch Ball engine. Steam is ordinarily carried at a pressure of 75 pounds which in a few minutes can be increased to 150 pounds. The switchboard is so arranged that power from the engine generator set can be used for every unit except the large hoist motor.

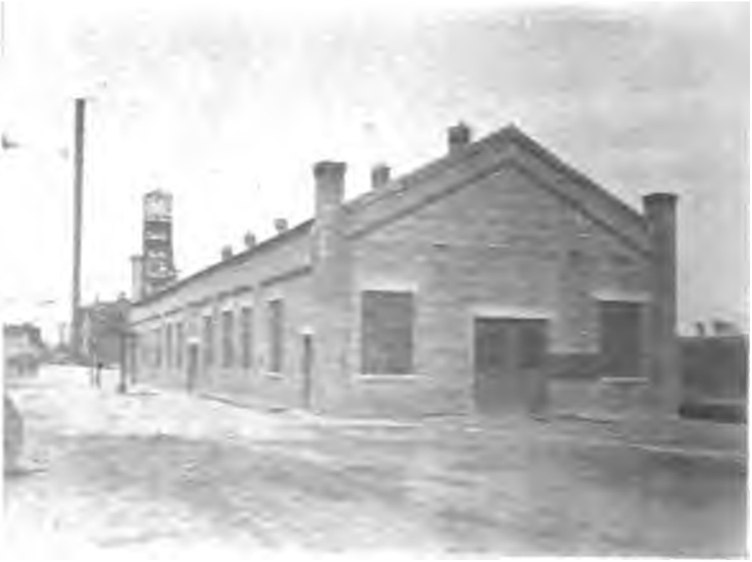

Fig. 5. Shop and Supply House.

In the power-house all electric cables are carried in conduit. Fig. 4 shows the switchboard with two motor-generator sets in the foreground.

Shop. The building containing the shop and supply house is 39 by 138 feet, divided into four compartments—blacksmith, carpenter, and machine-shops and supply house. See Fig. 5.

The blacksmith shop is equipped with two forges, a fan, and a hammer.

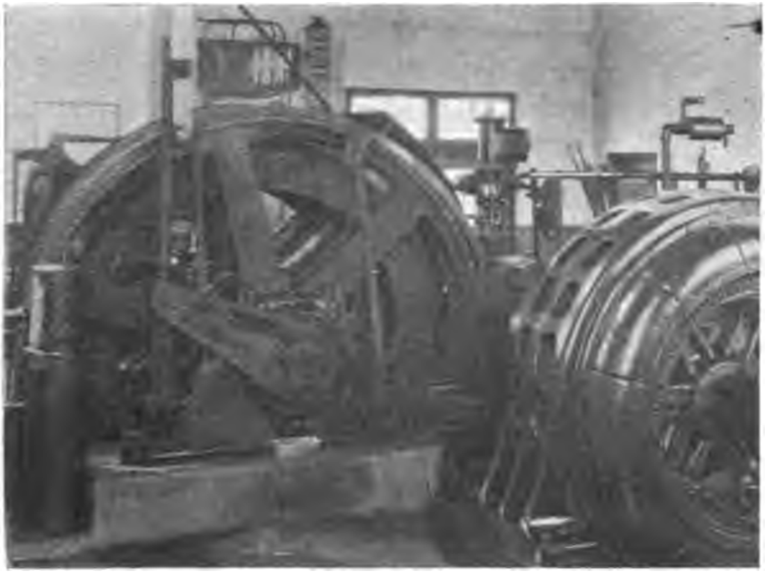

Fig. 6. Electric Hoist.

The carpenter and machine-shop contains a lathe, a hack-saw, a radial drill-press, a shaper and an emery-wheel. All machinery is operated by belt from a line-shaft driven by a 15-horse-power, alternating-current, 220-volt motor. The supply compartment is fitted with shelving and bins for handling the various supplies required around an operation of this sort. All material is strictly checked on arrival and passed out only on presentation of slips, properly signed, stating where and for what purpose the material is to be used. These slips are sent to the main office and the material charged in its proper subdivision. In the design of this building, special regard was given to light and ventilation. A track extends the full length through the middle, so as to facilitate the handling of material, mine cars and locomotives.

Hoist House. This building is located near No. 1 shaft and houses the hoisting equipment, which consists of a "Vulcan" hoist with cylindro-conical drums 7.5 to 10 feet in diameter. This hoist is operated by an Allis-Chalmers 1000-horse-power, alternating-current, 2200-volt, induction motor with liquid control, as shown in Fig. 6. This unit has been in operation for two years and has fully complied with the duties guaranteed by the manufacturers. An output of three cars per minute can be maintained, which insures a tonnage of over 3000 tons a day from the No. 1 shaft when the mine is sufficiently developed—at the same time hoisting the slate.

Fan House and Fan. Ventilation is afforded by a Jeffrey fan 14 feet in diameter and 6 feet wide, having an ultimate capacity of 350,000 cubic feet per minute, with a water-gage of 4.5 inches and requiring 322 horse-power at 150 r.p.m. During the first year this fan was in operation, it was driven by a 30-horse-power, variable-speed motor, capable of producing 150,000 cubic feet per minute at 79 r.p.m. At the end of the first year a variable speed motor of 100 horse-power was installed, the fan shaft being of sufficient length to provide for two pulleys of 100 inches in diameter. The second motor has just about reached its limit of capacity, and a third motor of 200 horse-power has been installed in the location of the 30-horse-power motor; the last motor will produce a maximum of 300,000 cubic feet of air against a water-gage of 3.3 inches when running at full speed of 490 r. p. m. Power is supplied at 2200 volts, either from the power company or the auxiliary supply, so that there is a double source of supply for power, and two motors, which practically insures against a shut-down on account of lack of ventilation. This was a point given great consideration by the management, as a stoppage of the air current is the most dangerous condition possible in a gaseous mine.

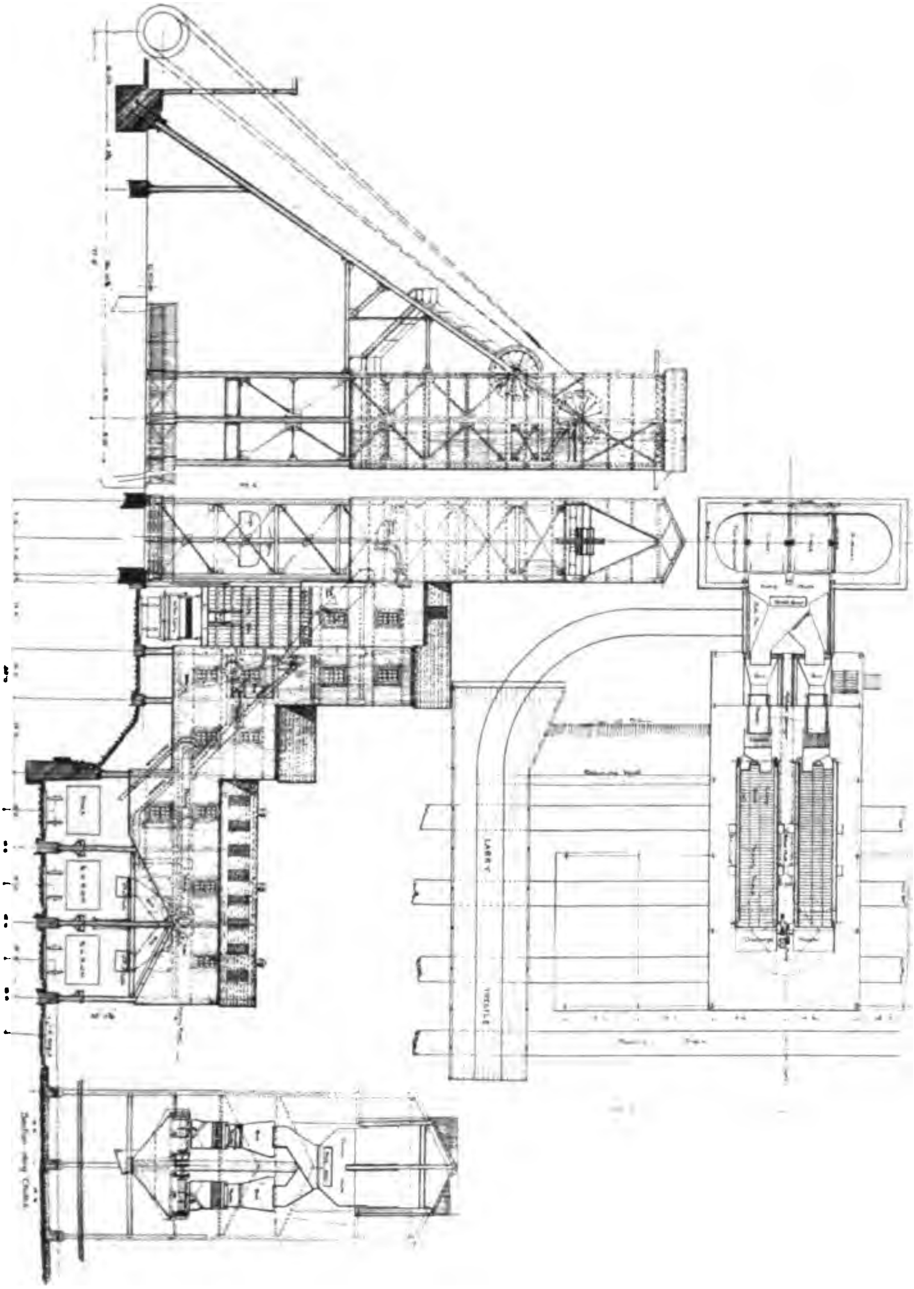

Fig. 7 Coal Tipple.

Head-Frames, Tipple and Bin. The head-frame and tipple are constructed of steel, concrete floors being installed in the tipple. See Fig. 7-9.

The coal is dumped from self-dumping cages into either of two bins located side by side, from which it is fed by reciprocating feeders over stationary screens five feet in length, separating the coal into three sizes and delivering it onto the picking tables. These tables are divided longitudinally into three compartments. The sizes are four inches and over, ¾ to 4 inches, and under ¾ inch. The center compartment one foot wide on the picking table handles the slack, and the two side compartments the other sizes. The coal is hand picked, the refuse being handled by a refuse conveyor to the slate bin immediately under the dump chute. The coal after passing over the picking tables is dumped into a receiving bin, from which it is loaded into cars on either of two tracks. The refuse from the mine is dumped direct into a bin of 50 tons capacity, from which it is loaded directly into a 10-ton electric larry and hauled across the railroad sidings on an overhead bridge to a refuse dump. This dump is of such a height that with the land available for dumping purposes it will, no doubt, serve the life of the mine. In case it should prove insufficient at its present height, the larry is able to operate on a six per cent. grade, so that an extra height of 20 or 25 feet can be utilized. The picking tables and feeders are operated by 15-horse-power, 220-volt motors

After the mine had been operating for a year, the development was seriously retarded by the prevailing car shortage, and the management decided to install some scheme for running the mine when it would otherwise be closed for lack of railroad cars. After considerable thought, it was decided to build a storage bin of 1000 tons capacity, provision being made for increasing it to three or four thousand tons, if necessary. It was so arranged that the coal is taken from the end of the picking table on a pan conveyor, delivered to a 36-foot belt conveyor, elevated to the top of the bin, and distributed by an automatic tripper. Another conveyor was installed at right angles to the bin, from which the coal is discharged to the ground and piled to the side by a "Brownhoist" with a 70-foot boom. Coal from the pile is re-

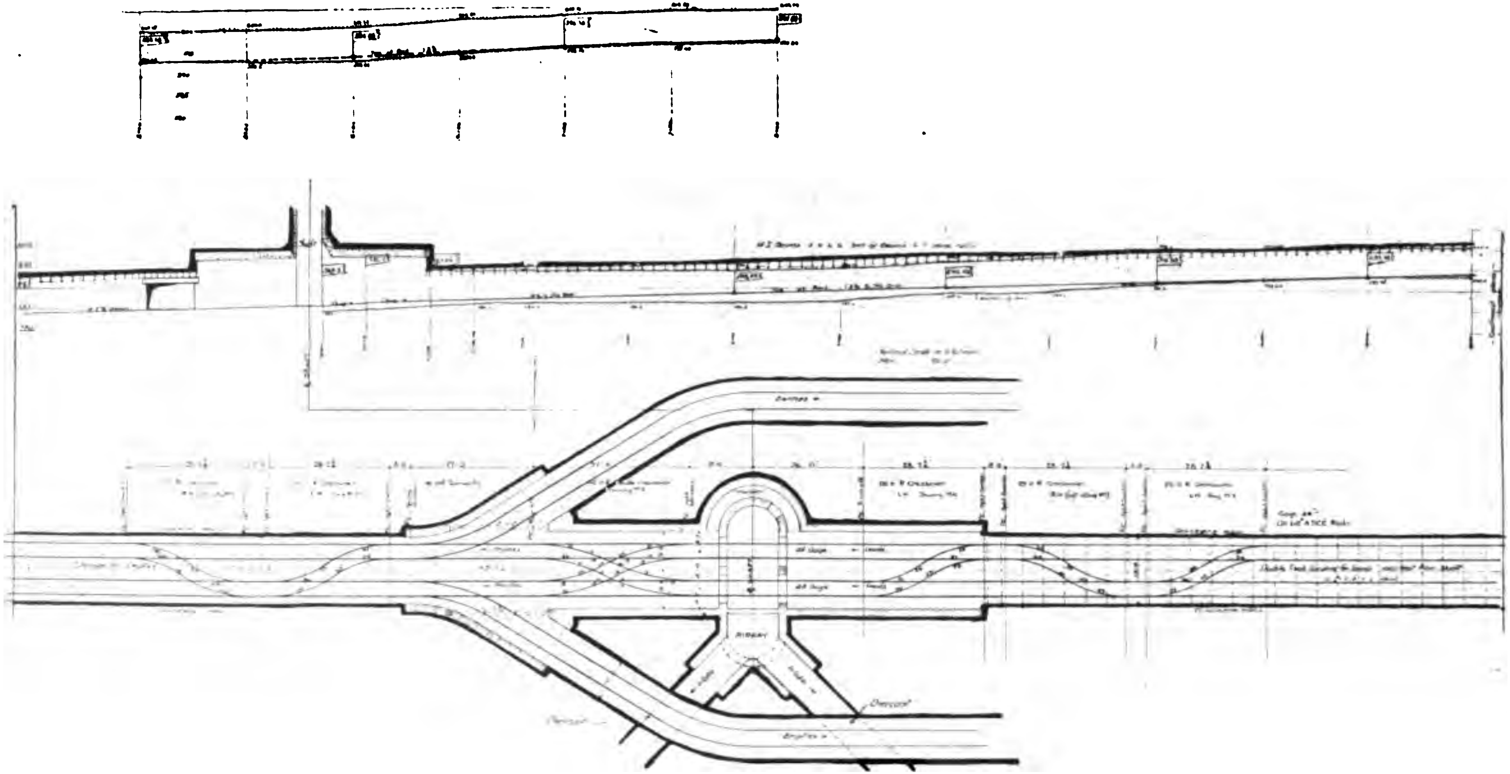

Fig. 10. Track Lay-Out at Shaft Bottom.

at this point will be erected when the mine is developed to supply sufficient tonnage.

Lamp House and First Aid. This building is located near the power-house at No. 2 shaft. It is a two-story structure, the second floor being devoted to instruction in rescue work, etc., meetings being held once a week. The lower floor contains the lamp house, mine foreman's office and first-aid room.

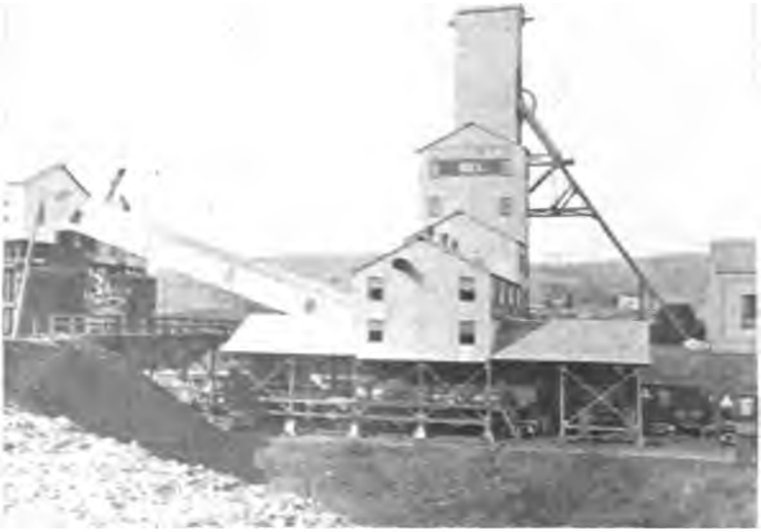

Fig. 9. Tipple and Conveyor to Storage Bin.

MINE DEVELOPMENT AND UNDERGROUND EQUIPMENT

As will be noted, the shafts are located 850 feet apart on a line parallel with the railroad sidings and 100 feet north of the track. After reaching coal the primary object was to connect the shafts. This was accomplished by driving principally from No. 2 shaft, from which point the early development was done. This was necessary so as to complete the concrete work at the bottom of No. 1 shaft and install tipple and hoisting machinery.

After the shafts were connected, work was concentrated on two headings from No. 1 shaft, so as to complete the landing. Fig. 10 gives an idea of the construction and grades at this point.

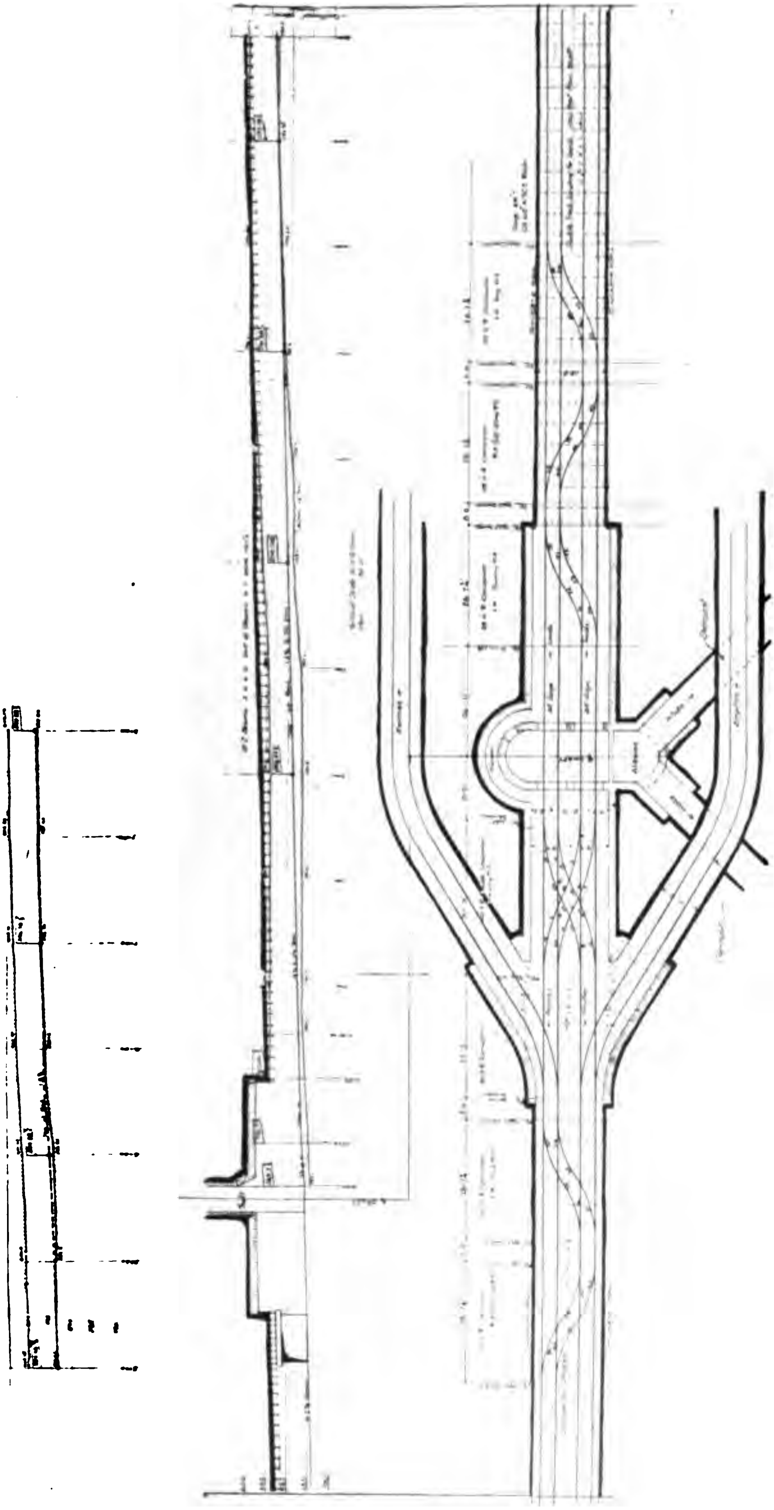

Fig. 10. Track Lay-Out at Shaft Bottom.

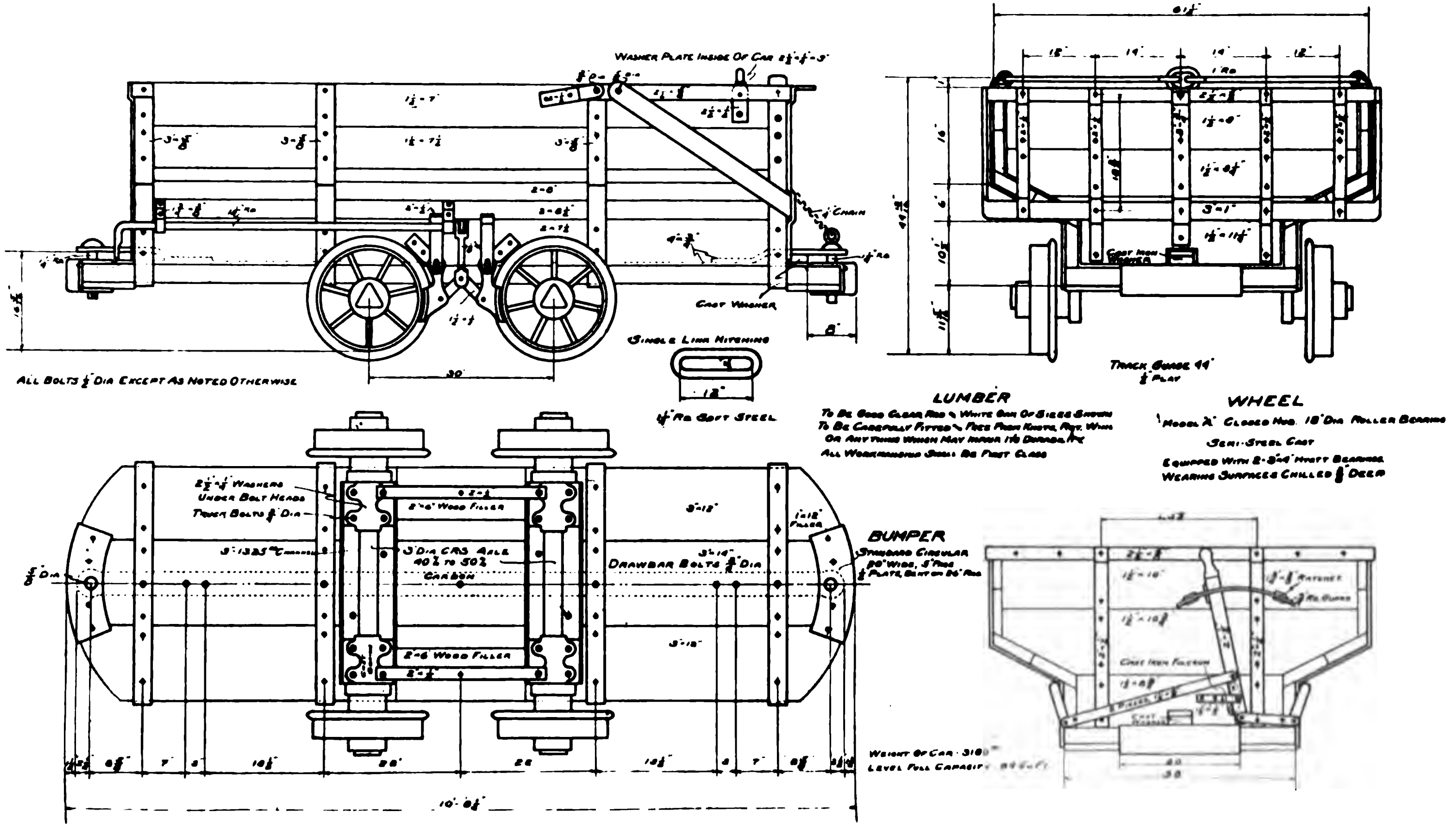
Washer Plate Inside Of Car 2½-½-5"
Chain
Cast Washer
Single Link Hitching
1½" Rd. Soft Steel
All Bolts ½" Dia Except As Noted Otherwise
Track Gauge 44"
½" Play
Cast Iron Washer
LUMBER
To Be Good Clear Red & White Oak Of Sizes Shown
To Be Carefully Fitted & Free From Knots, Rot, Wane
Or Anything Which May Impair Its Durability
All Workmanship Shall Be First Class
WHEEL
"Model A" Closed Hub. 18" Dia Roller Bearing
Semi-Steel Cast
Equipped With 2-3×4" Hyatt Bearings
Wearing Surfaces Chilled ⅜" Deep
2½-¼ Washers Under Bolt Heads
Truck Bolts ⅝" Dia
2'-6" Wood Filler
3" Dia CRS Axle 40% to 50% Carbon
Drawbar Bolts ⅞" Dia
1×12" Filler
BUMPER
Standard Circular
20" Wide, 5" Rise
½" Plate, Bent on 26" Rad
Weight Of Car · 3180
Level Full Capacity
Cast Iron Fulcrum
Ratchet
10'-6½"
6'-1½"

FIG. 12. Details of Mine Car.

1920	Tons
November	23,300
December	26,950
1921	
January	26,900
February	33,300
March	34,700
April	36,500
May	37,500
June	42,100 (estimated)

The production has reached 2000 tons a day this month and is constantly and uniformly being increased.

Mining conditions are very good, the only drawback being exceptionally heavy draw slate in some sections of the mine but this is thought to be a merely local condition.

TOWN-SITE

Topographical conditions were favorable for a splendid town-site and the management decided that it was imperative to provide the best living conditions possible in order to attract the better class of mine labor. The tract of land available is of sufficient area to provide for 500 or more houses and yet provide sufficient space for each house. The streets are laid out to suit the topography and provide good drainage.

Fig. 13 shows the lay-out and the houses built to date. Lots are 80 feet in width and from 105 to 120 feet in depth. The houses are built 20 feet back from the street line. Each house has water and sewerage. "Sanisep" closets are installed and have proven entirely satisfactory. Most of the streets have been macadamized with crushed slag with a coating of limestone screenings. Sidewalks of Cleveland sawed stone are laid. Ample fire protection is furnished from two 50,000-gallon tanks, located on a hill nearby, giving a pressure of from 60 to 80 pounds throughout the town. Shade trees have been planted along the streets, so that in a few years there will be no evidence that it is a coal-mining town. Houses contain from three to six rooms each, but the five-room houses as shown in Fig. 14 are in most demand.

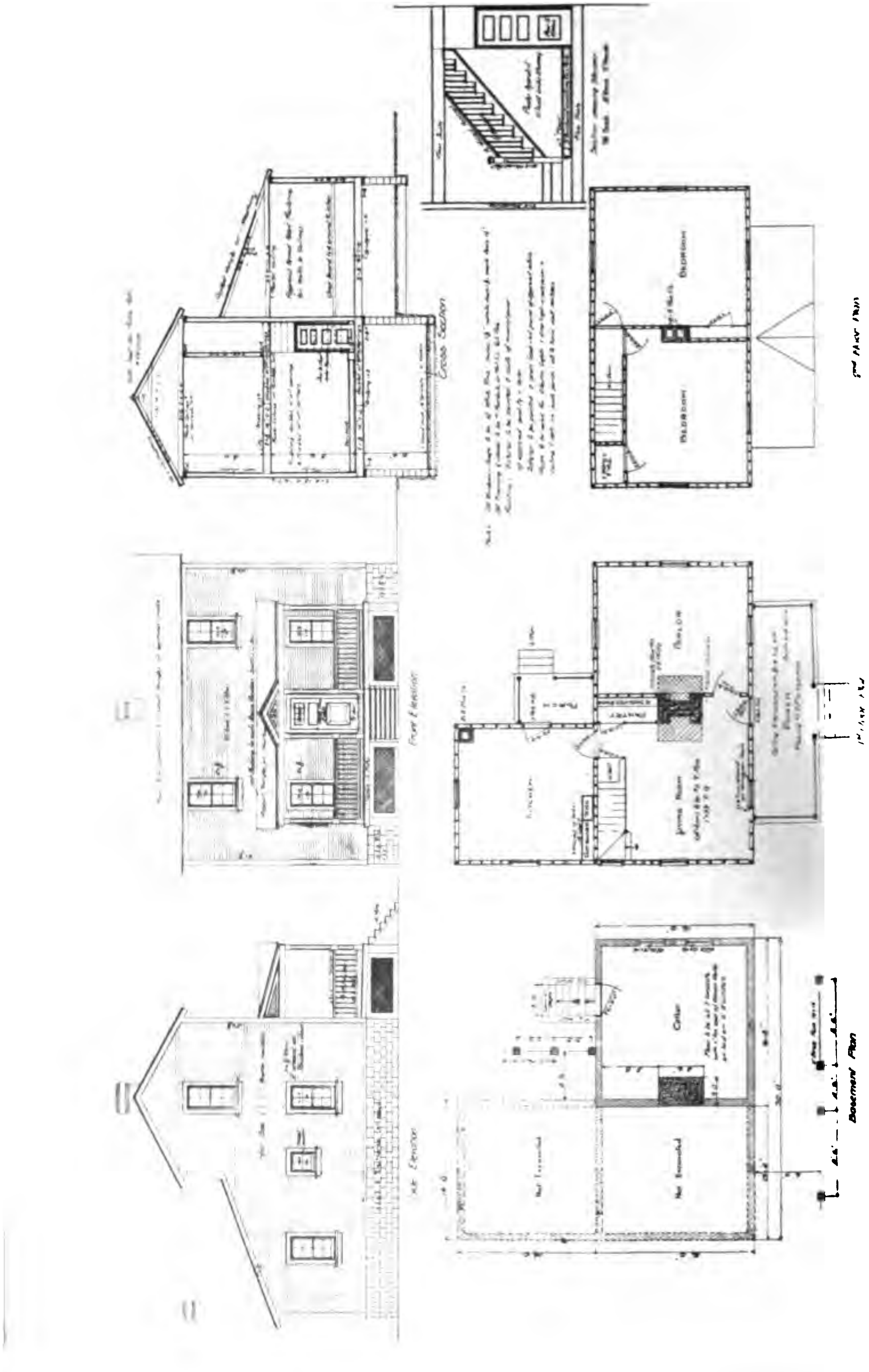

Fig. 14. Details of Five Room House.

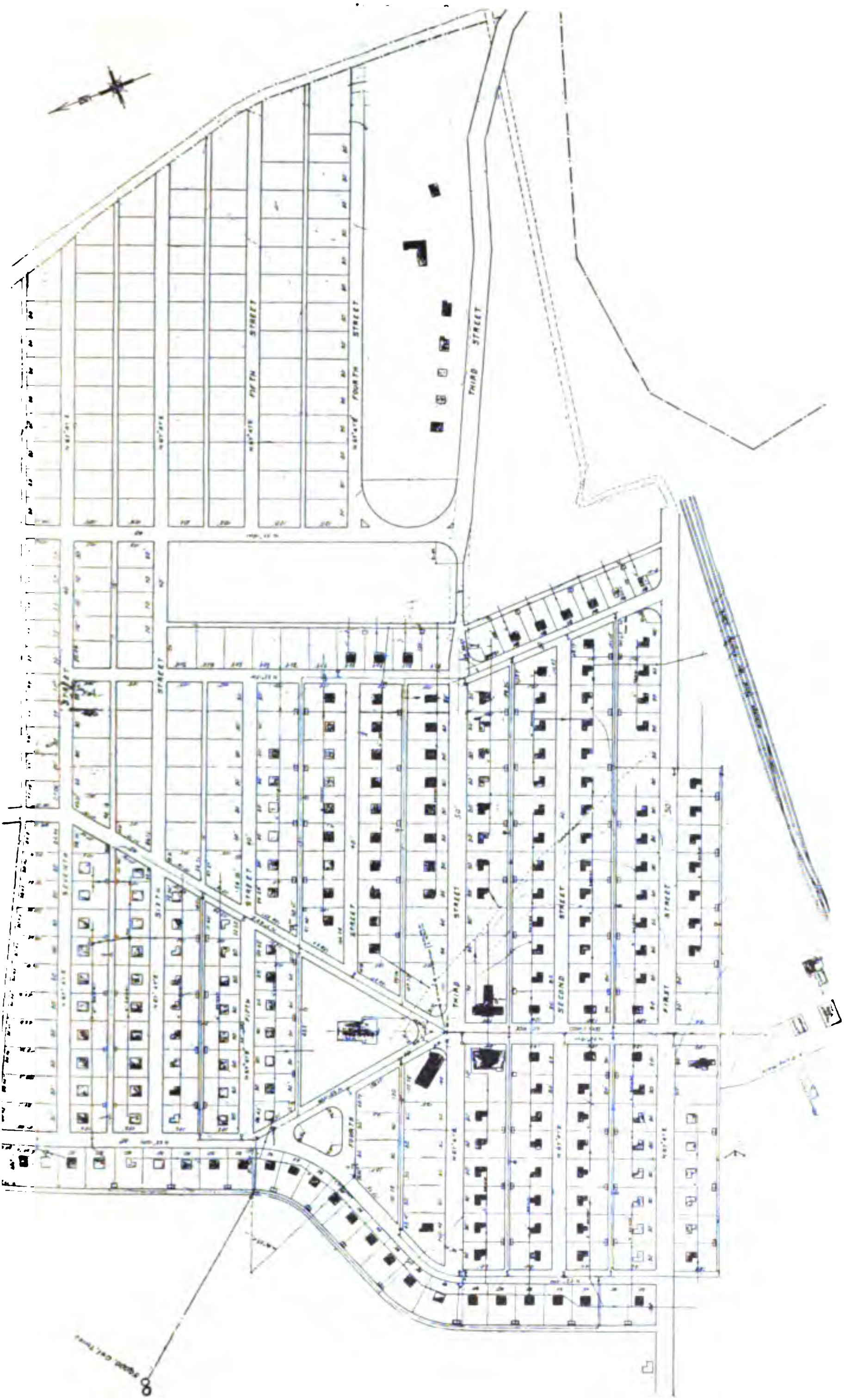

Fig. 13. Lay-Out of Town.

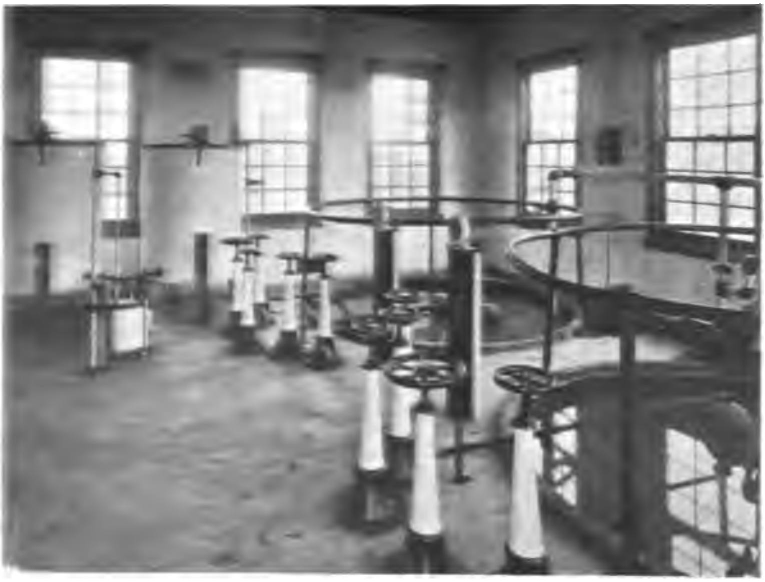

Fig. 16. Operating Floor of Filtration Plant.

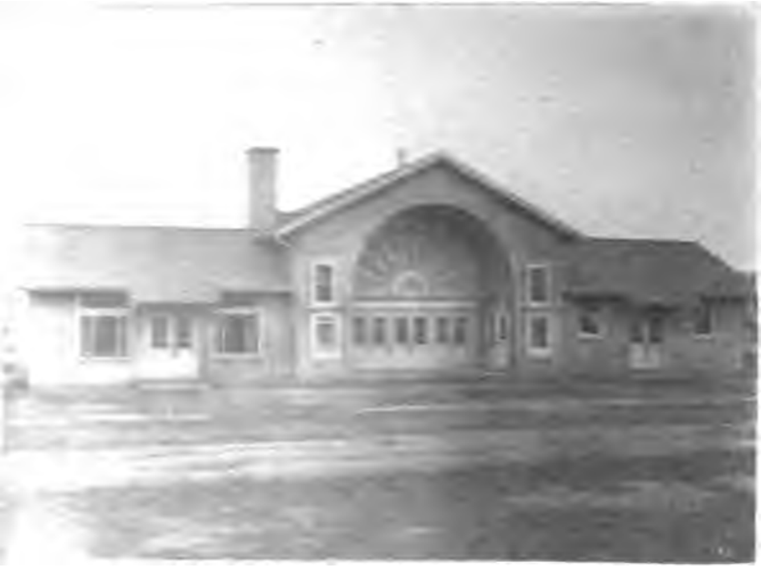

Fig. 17. Moving Picture Theater. Confectionery in Left Wing; Library in Right Wing.

operation, in which all the latest and best pictures are shown several nights a week, at prices merely sufficient to pay for management and upkeep. See Fig. 17.

On the opposite corner of the square is a recreation building containing bowling-alleys, pool-tables, and barber shop on the first floor, with a large dance-hall on the upper floor. The need for such a building in a community of this sort is evidenced when parties will come miles from surrounding country to attend functions and dances held in it. See Fig. 18.

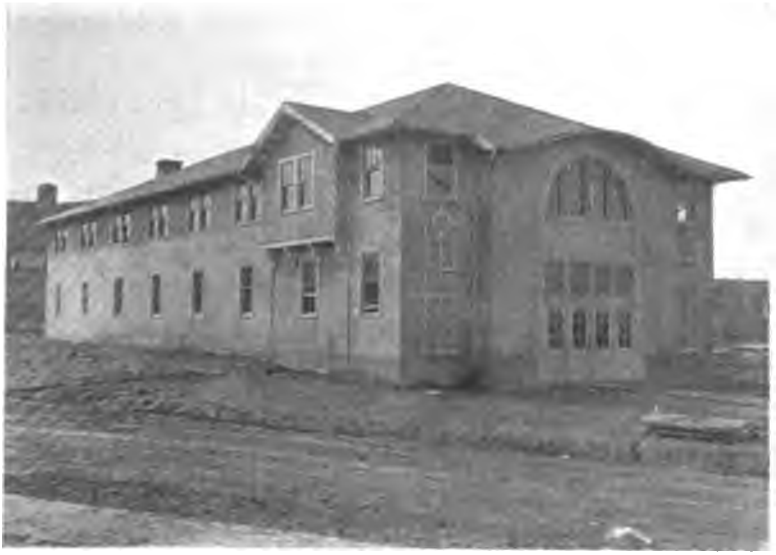

Fig. 18. Recreation Building.

The town supports a baseball club which rendered a good account of itself last season and promises to do the same this year.

A modern school takes care of the educational needs of the young members of the community. Religious services are held in the various buildings and sites have been reserved for those congregations who wish to erect their own church edifices.

The company has a welfare worker and nurse, whose duty it is to visit the families and instruct them in American ways of living. For the young single men and bachelors among the operating force, a club-house with all modern conveniences affords a quiet home. See Fig. 19.

Taking all things into consideration, the town of Mather is located in one of the most charming spots in Western Pennsylvania and no effort or money has been spared to keep the town in harmony with its surroundings.

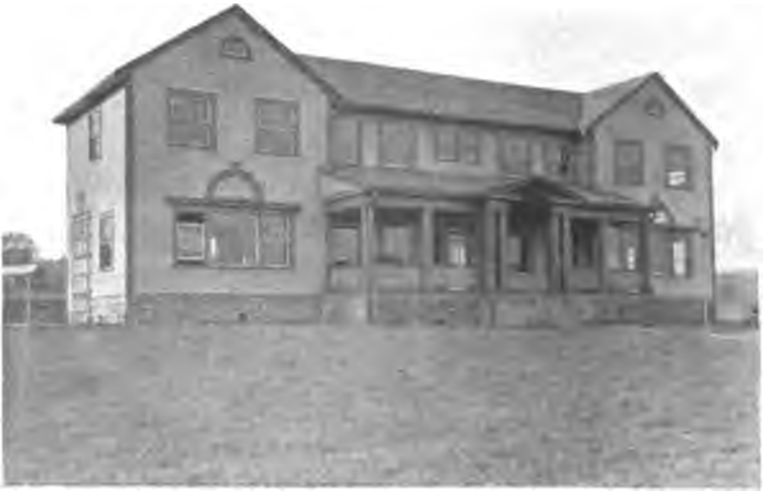

Fig. 19. Club-House.

In conclusion, our firm wishes to express its acknowledgment to the various persons connected with the enterprise, for their hearty co-operation in bringing about the final consummation of the project, it being carried on under war-time conditions. Among those deserving of special mention are: Frank Armstrong, of Pickands, Mather and Company Cleveland, General Manager; the late W. L. McDonald, Superintendent during the greater part of the construction; J. Herbert Evans, assistant superintendent, and now superintendent; W. H. Crofts, designing engineer; A. E. Bicht, engineering draftsman; C. W. Kurtz, resident engineer on the work; and John C. Graham, architect, of Cleveland, who designed the various civic buildings.

DISCUSSION

Mr. W. A. Weldin, *Chairman*:* We are very glad that through the medium of the Proceedings this excellent paper will have a larger audience than is here this evening. I am sure the engineers who are here will profit by the evening. The paper is extremely interesting to me and I am sure it will be valuable. Mr. Elliott will be glad to answer any questions and we will be glad to hear any remarks. This is not a paper that is subject to such discussion as a theoretical paper would be, but it is perhaps more valuable because it represents work actually carried out. I should like to ask if the stairway in the shaft will be of concrete.

Mr. J. R. Elliott: There has been no stairway built in the shaft to date. According to the state mining law, it is not necessary for a stairway to be installed for a shaft of this depth, and on account of the fact that there is an auxiliary power-plant, which will take care of the hoisting of men, it was not deemed necessary to install the stairway. However, provision was made for it and it will be built of steel with Irving grating treads.

Mr. Earl V. Braden:† I think the speaker's modesty prevents him from telling how much the completeness of detail and the construction during the trying times of the war period were due to Mr. Elliott. I was connected with the railroad during that period, and at the time when men were scarcest and material impossible to get and the railroad officers of the Director General in charge would give up the ship and say to stop work, Mr. Elliott and Mr. Armstrong would get behind the project and the first thing we knew we would hear from Washington "Don't let the work on Ten Mile cease," from someone at Washington that everybody knew.

We were especially glad to see the Mather Collieries completed, and in such a complete manner. We hope our railroad in that neighborhood in due time will be as complete as the collieries plant.

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*Blum, Weldin & Co., Pittsburgh.

†Engineer, Pittsburgh, Chartiers & Youghiogheny Railway Co., Pittsburgh.

Mr. John M. Rice:* As a municipal engineer I have been greatly interested in the lay-out of the town and I would like to ask Mr. Elliott if he can give us the approximate difference in cost per ton of coal mined between a development having a mining town such as he has shown, with modern houses, well built and well arranged and with satisfactory conveniences, and another having a town with the old-style two-family houses. I believe that would be of considerable interest to a large number of the members of this Society who frequently have to explain why it is necessary to spend a little more now on mine-housing development than it was in the past. I have been connected with several developments in which special emphasis has been laid on the housing facilities, and I think the cost of the housing must be a very small percentage of the total cost, based on the tonnage, and if he has any figures of that nature they will be of interest.

Mr. J. R. Elliott: We have no figures available, such as Mr. Rice requests. When the housing question for this plant was considered, the management decided it wanted the best arrangement for housing that it was possible to procure, and decided that only single houses on large lots would be considered. The average cost of the five-room houses, including out-house, fence, etc., has been from $2200 to $2500 each. Six or seven years ago we built eight-room double houses for $1400 each; so that the cost of the single houses on individual lots is approximately three times the cost of the single house along the old lines.

The main reason for constructing the single house is that it creates a great deal more contentment among the occupants, especially the women, when they have their own houses and yards. The chances are, when a man takes his family into such a community they are more likely to stay than where the living conditions are not so favorable.

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*Consulting Engineer, Pittsburgh.

Mr. W. A. Weldin: When you consider the difference in first cost the increase is not very great, even comparing the cost of these single houses with the double block of some years ago.

Mr. J. R. Elliott: The present cost is about three times as great.

Another item to be taken into consideration in the construction of the first 100 houses is, that all the material had to be hauled by wagon or truck a distance of five or six miles, which greatly increased the cost of construction.

. Mr. John M. Rice: $2300 for those houses seems to me to be a remarkable tribute to somebody. I do not know who could build them at that rate during this period, because I know a number of developments carried out at the same time where houses considerably less elaborate ran up over $5000 and $6000. I hope Mr. Elliott will emphasize in his printed paper that side of the question, because I know we have found it difficult to convince the mine operators that a very small percentage of increase in cost will give them housing conditions which will not only increase the efficiency of their labor but will actually attract and keep labor at times when there is a tremendous demand.

Mr. W. A. Weldin: The best argument is the actual practice of experienced operators.

Mr. J. R. Elliott: We have built houses of three, four, five and six rooms, but the five-room house is the one which is most in demand and will probably be the type built in the future.

Mr. John M. Rice: Is that due to the fact that five-room houses will allow them to keep boarders?

Mr. J. R. Elliott: No, I think not.

Mr. Earl V. Braden: Do you charge a higher rent for the five-room houses?

Mr. J. R. Elliott: The rentals charged for the houses are as follows:

Three room house, $8; four-room house, $9.50; and five-room house, $11 a month.

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VOL. 37 JANUARY 1922 No. 10

PROCEEDINGS

OF THE

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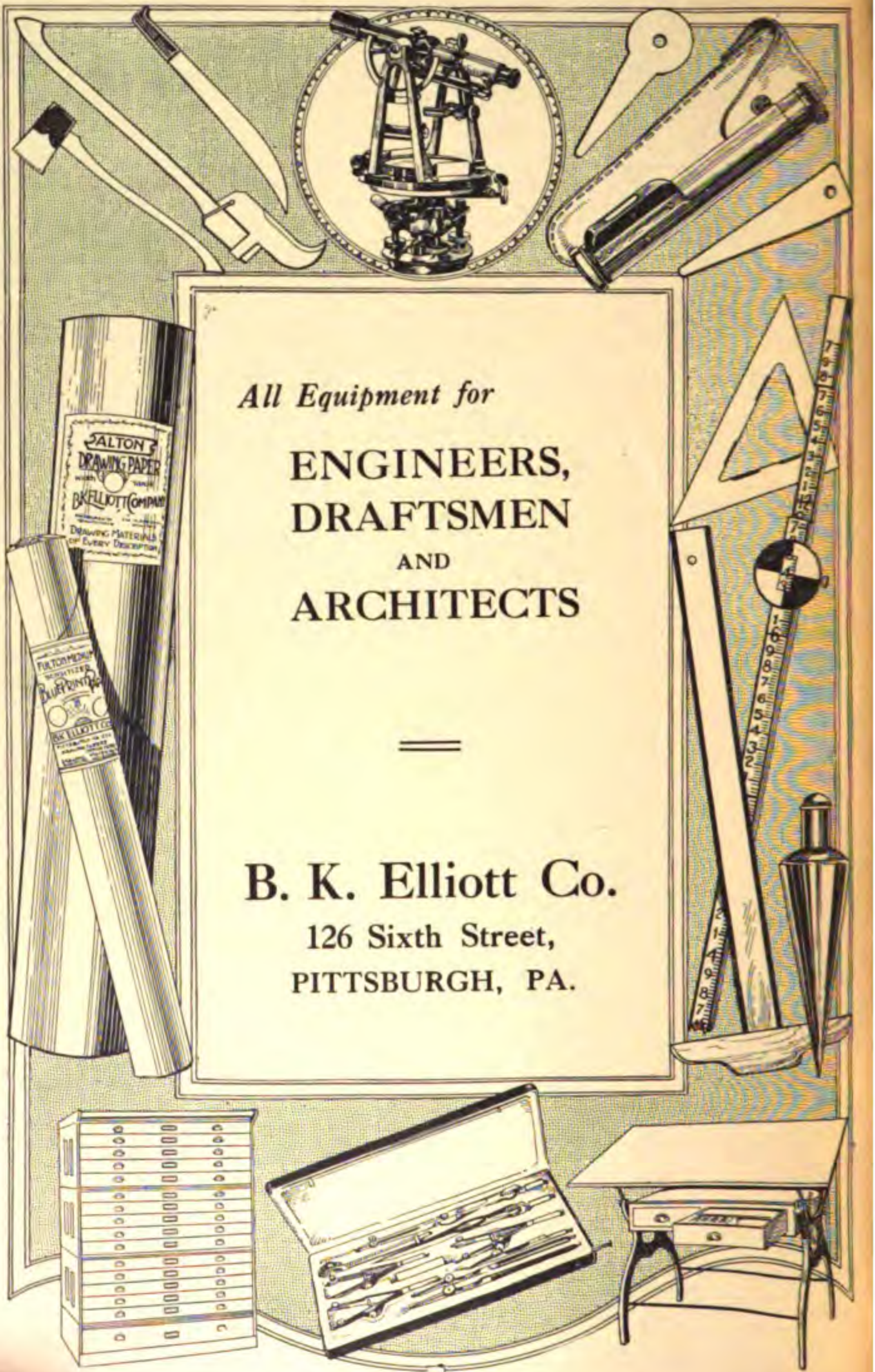
THE PITTSBURGH TRAFFIC COUNT - - - - *Winters Haydock*
A MAJOR STREET PLAN FOR PITTSBURGH - - - *C. L. Wooldridge*

PITTSBURGH
UNION ARCADE BUILDING



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THE PITTSBURGH TRAFFIC COUNT

BY WINTERS HAYDOCK*

INTRODUCTION

A number of years ago an acquaintance of the writer who was a professor of physics prepared a very slow-acting photographic plate and took a picture showing several blocks of one of the busiest streets of the central business district of the city of St. Louis. The picture was taken during the middle portion of a week-day, the exposure being of about two hours duration. But when the plate was developed the only living creature to be seen was an old horse hitched to a wagon and standing with drooping head near the curb. Of the thousands of animate objects which had passed before the lens of the camera during those noonday hours, he and he alone had left his impression. Why? Because he had never moved.

Now the philosopher or the moralist might draw many a lesson from the symbolism of the old horse and his unique attainment of perpetuity, but to the more simply and prosaically minded citizen, particularly if he be an automobile user, the first thought to occur would be that the old horse stood for a symbol of the good old days when a man might leave his conveyance at the curb for two hours without coming back to find it all gaily decorated with fluttering tags of red.

But to the thoughtful engineer the peaceful and undisturbed posing of the old horse on the most crowded business street of a large city may have a more serious significance, if due regard is given to the fewness of the years in which such great changes in the aspect of such streets have taken place. He will come to a realization of the probability that, if in so short a time there has been such a tremendous evolution in the traffic conditions of our large cities, still greater changes must be provided for in the years to come if our cities are to continue to function. The American characteristic of rapid adjustment to changed conditions is apt to carry with it a forgetfulness of the fact of the change. We are apt to forget that the traffic problem as we have it to-day is the product of but a decade and a half of development and that the next decade and a half may bring about a change equally great.

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*Chief Engineer, Citizens Committee on City Plan of Pittsburgh, Pittsburgh.

It has been stated recently that automobile ownership will soon reach the saturation point and that thereafter its increase will be only in proportion to the increase in population. That there has been as yet any approach to the saturation point is a very dubious contention at least in so far as passenger vehicles are concerned. As to commercial vehicles, their tonnage in any community will probably increase in proportion to the growth of the business of the community for any given distribution of industrial and residential districts and of railroad facilities; and the growth of business may well be expected to be in proportion to the growth of population. But a little consideration will show that we have no justification for believing that we have even approached the limits of the ratio of pleasure vehicles to population. For example, we cannot predict to what degree improvements in manufacturing methods and consequent reduction in cost may extend the possibility of automobile ownership to portions of the population not now able to afford them; and again, the cumulative effect of acquired habit will have its important influence, as those who are owners of cars to-day will in most cases cease to be owners of cars only through dire necessity, while their number will constantly be augumented by additions from those who, though economically able, have not yet acquired the automobile-owning habit. Furthermore, it is to be expected that with reduced costs of manufacture the more-than-one-car families will begin to multiply greatly; and this will not be confined to the wealthy classes. Dad will not let big brother use his car to take the girls riding in, so brother buys his own car; and will big brother lend his car to sister and her flighty friends? He will not! So sister buys one for herself.

But I believe that there is an influence in operation to-day which, more than any other, is holding down the ratio of automobiles to urban population, and that the gradual removal of this influence will open the way to an unprecedented increase in this ratio. I refer to the lack of housing facilities for the cars. There are thousands of families to-day without cars simply because they have no place in which to keep them. We may look to our friends, the architects, for the gradual correction of this condition. It is less than two generations back since some members of that profession were building houses without bath-rooms. To the next generation it will seem equally astonishing that certain architects of the present day were still building dwellings without providing a place for an automobile for each family, or perhaps a place for more than one automobile.

All this is by way of emphasizing the imminence of an unsolved problem which may possibly become more serious than we now anticipate—the problem of adapting the street systems of our cities to a tremendously increased traffic burden, a burden for which they were in no wise designed; and upon whom will rest the responsibility for getting us out of this predicament if not upon the engineer—the final repository of all the toughest problems of humanity? And working side by side with him will be the practitioner of that new professional specialty, the city planner—that new type of pest, as he appears to some, who has come to harass us in the slumber of our complacency.

Now, if we are to square ourselves to the job of anticipating in our large cities a condition of traffic congestion (the seriousness of which may not be calculated) by forehandedly applying such remedies as may be within our power, we must begin by a careful scrutiny of existing conditions. This implies, first, a study of the existing plan of streets to determine upon a scheme for the arterial system of major thoroughfares as distinguished from the secondary or local streets of the general system. It is most important that in developing a city plan this distinction be as clearly drawn as circumstances will permit. Only by the development of a clearly defined system of continuous arterial thoroughfares of adequate capacity can proper circulation for the whole locality be assured.

One of the primary objects of the Citizens Committee was the producing of a plan for such a system of main thoroughfares.

The traffic count was made as an incidental aid to the working out of this major street plan. It is not my intention to discuss the major street plan to-night, as it will probably be discussed later before this Society.

The traffic count was undertaken with a full appreciation of the fact that there are certain limitations to its value as a guide to the development of a street plan. Artificial or non-permanent conditions may materially affect the use of certain streets. The condition of the paving, for example, may have an important influence on the traffic using a given route; or the making of new connections and the opening of new streets may completely dislocate the existing traffic equilibrium. At best, a traffic count can be considered only as a useful aid.

THE TRAFFIC COUNT

In the fall of 1920 the Citizens Committee on City Plan decided to make a vehicular traffic count as a help to the study of the major street plan which it was then undertaking. An investigation showed that to make a complete and thorough count covering all portions of the city, with a sufficient number of counting points to determine in detail the movement of traffic along, into, and from all of the principal streets, would involve an expense for which it did not appear that sufficient funds could be made available. The Committee would have preferred to make a comprehensive count of this character, covering in detail the entire city, but it was necessary that the expenses be confined within practicable limits. The co-operation of the City Planning Commission was sought and secured, and its Chief Engineer, Mr. U. N. Arthur, assigned the work of assisting the Citizens Committee in the count and tabulation to the staff of the Transit Commission, which was at that time functioning under the direction of the City Planning Commission. Mr. A. B. Carr was assigned to take active charge of the work.

As this was to be of considerable interest to the city, and particularly to the City Planning Commission, as well as to the Citizens Committee, it was agreed that there should be a division of expenses, the arrangement being that such city employees as were available would be used for the count and the clerical work, while the remainder of the force necessary would be employed and paid by the Citizens Committee.

In view of the impossibility of making a city-wide count with the means available, it was decided that the scope of the count should be confined to a study of traffic affecting the central business area or the areas adjacent thereto, together with traffic at a few special exterior points of particular interest in developing the major street plan. In so far as the investigations applied to the triangle district (the central business district, between the Allegheny and the Monongahela west of Grant Street) the objects of the count were two-fold: first, a study of traffic passing through the various entrances of the triangle as to both quantity and type, and of the principal routes of dispersion of that traffic beyond these entrances; and second, a study of the traffic passing into the triangle to determine the percentage and routes of that portion which passed through merely as part of a trip between two districts outside of the triangle. It was believed that the percentage of this latter class of traffic would be found to be large and that, if it could be removed from the triangle by the development of a system of by-pass thoroughfares, there would result an appreciable measure of relief for the congestion of the triangle district.

It was decided to make no counts inside of the encircling ring of entrances to the triangle. Such counts might be of value in studying certain phases of the traffic problem within the triangle, but would not be necessary to the objects of the count as decided upon.

In order to determine the number of vehicles passing through the triangle on through trips it was necessary to devise a means of identifying each individual vehicle as it passed the various counting points. Several plans for this were discussed. The only feasible one appeared to be the recording of the license number of every vehicle passing each of the counting points, together with the time and direction of its passing. It was realized that this would be a very difficult thing to do at points

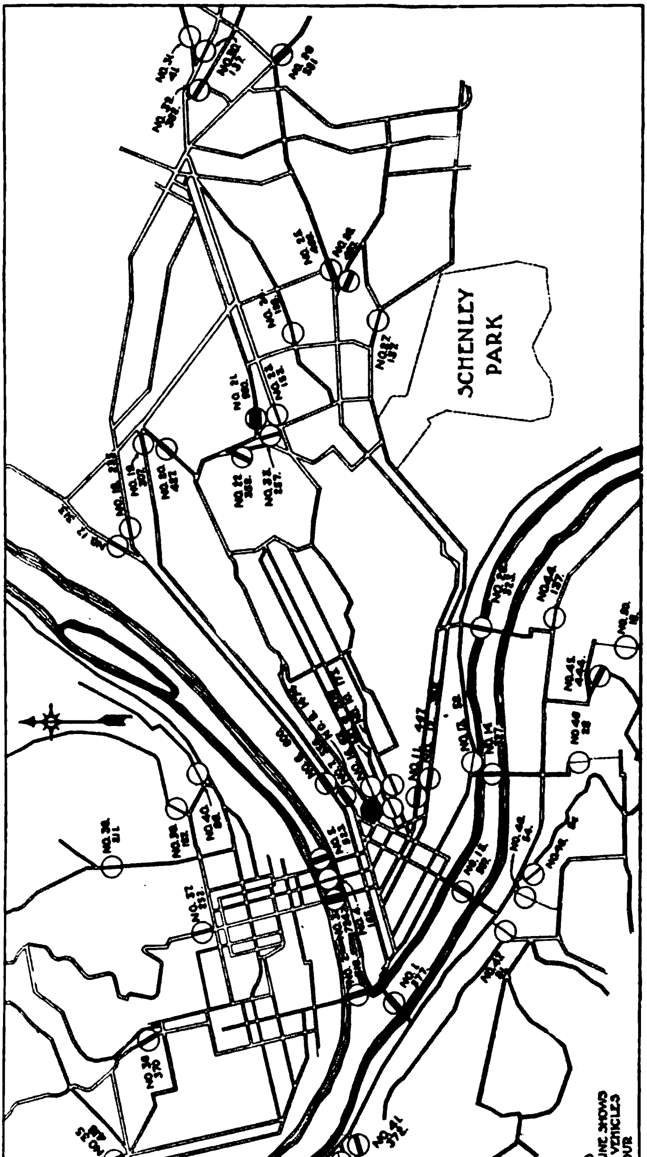


Fig. 1. Location of Counting Points and Amount of Traffic for Hour of Maximum Flow. Figures at Counting Points Indicate Number of Vehicles.

'S

R OF MAXIMUM TRAFFIC BOTH DIRECTIONS		
TIME		TOTAL VEHICLES
From	To	
4:45	5:45	577
4:45	5:45	518
1:45	2:45	724
4:30	5:30	165
7:45	8:45	523
2:45	3:45	600
3:00	4:00	556
4:45	5:45	1474
5:00	6:00	209
1:00	12:00	173
3:30	4:30	497
4:30	5:30	368
3:15	4:15	58
4:45	5:45	327
9:00	10:00	507
5:00	6:00	93
3:15	4:15	313
8:00	9:00	235
5:00	6:00	307
4:45	5:45	427
4:00	5:00	980
4:30	5:30	352
4:30	5:30	153
8:00	9:00	128
4:15	5:15	498
8:15	9:15	403
2:45	3:45	137
4:15	5:15	323
5:00	6:00	581
2:30	1:30	137
4:45	5:45	41
5:00	6:00	382
4:45	5:45	257
8:30	9:30	104
4:45	5:45	416
5:00	6:00	370
5:00	6:00	252
5:00	6:00	211
3:45	4:45	127
0:15	11:15	86
5:00	6:00	372
9:30	10:30	21
3:30	4:30	186
0:15	11:15	137
4:45	5:45	444
5:00	6:00	94
7:30	8:30	81
7:30	8:30	54
9:00	10:00	28
0:00	11:00	18
8:00	9:00	74

of heavy traffic flow; but experiments were made which indicated that a proper number of checkers could obtain results having a very high percentage of accuracy. So far as the writer knows, a count of this character has never before been attempted.

Fifty-one counting points were chosen, each point being designated by a number. The first 16 of these are the entrances to the triangle. The remainder are located on the principal thoroughfares at various distances from the triangle, and form something like a belt around it. There were 17 of these external counting points in the central and East End district, 7 on the North Side, and 11 on the South Side. The exact location of each point is given in Table I (insert) and its approximate location is indicated on the chart shown in Fig. 1.

A schedule was made out showing the number of men which it was believed would be required to do the checking at each counting point, this number being based upon the estimated weight of traffic at each point. This schedule also provided for a number of traveling relief men who were to go from point to point as needed. It also divided the counting points into five districts, each to be under the care of a supervisor or foreman.

Arrangements were made with the Dean of the School of Engineering of the University of Pittsburgh for the employment of students of that school to help in the counting. It was arranged that those so employed were to be released from attendance upon classes upon the day of the count. The co-operation of the faculty and students of the School of Engineering contributed very largely to the success of the count. Students were employed to the number of 136, and city employees to the number of 75. The students were paid at the rate of 60 cents an hour, which was the standard rate for student work at the University during the period of high wages then prevailing.

The count was made on Oct. 28, 1920, between the hours of 7 a.m. and 6:15 p.m. Had the count been undertaken earlier in the season the time of ending would have been chosen as 7 p.m., but at that season of the year it became too dark to read numbers accurately shortly after 6 p.m.

On the day before the count an instruction sheet was given to each checker indicating in full his location and duties, together with the symbols and methods to be used in recording. He was also given a blank record book.

All license numbers were recorded, one squad recording traffic in one direction only. The record was subdivided into 15 minute periods by turning a new page in the book at the end of each period and marking the time at the top of the next page. Motor trucks and commercial vehicles were designated by the symbol T and horse-drawn vehicles by H, while army and mail trucks were designated by A and M respectively. As no license number could be recorded for horse-drawn vehicles or for army and mail trucks a numerical record only was obtained of these.

The work of tabulating the count proved to be more laborious than that of making it. A tabulation was first made showing the number of vehicles of each class passing each counting point by 15-minute periods, a separate sheet being used for each counting point. As the object of the count required that the record of appearances of each vehicle at the various counting points be so consolidated as to make its movement traceable, it was necessary to devise a means to assemble the scattered notations for each individual vehicle. To accomplish this expeditiously required considerable study, as the total number of appearances of vehicles recorded was 131,021.

The following method was employed: The record of each appearance of a vehicle was copied upon a separate card, the cards being slips of paper two by four inches in size. The record on each card included license number, type of vehicle, time period, direction of travel, and identity of counting point by number. These cards were then sorted by hand into numerical order according to license number, and this automatically brought the cards for any one license number together. This sorting was a very laborious process, but was expedited by several ingenious methods.

The record from the cards was then copied on printed forms 17 by 26 inches in size—one horizontal line being given to each license number. These sheets were ruled vertically for the time of day, each 15-minute period having a separate column.

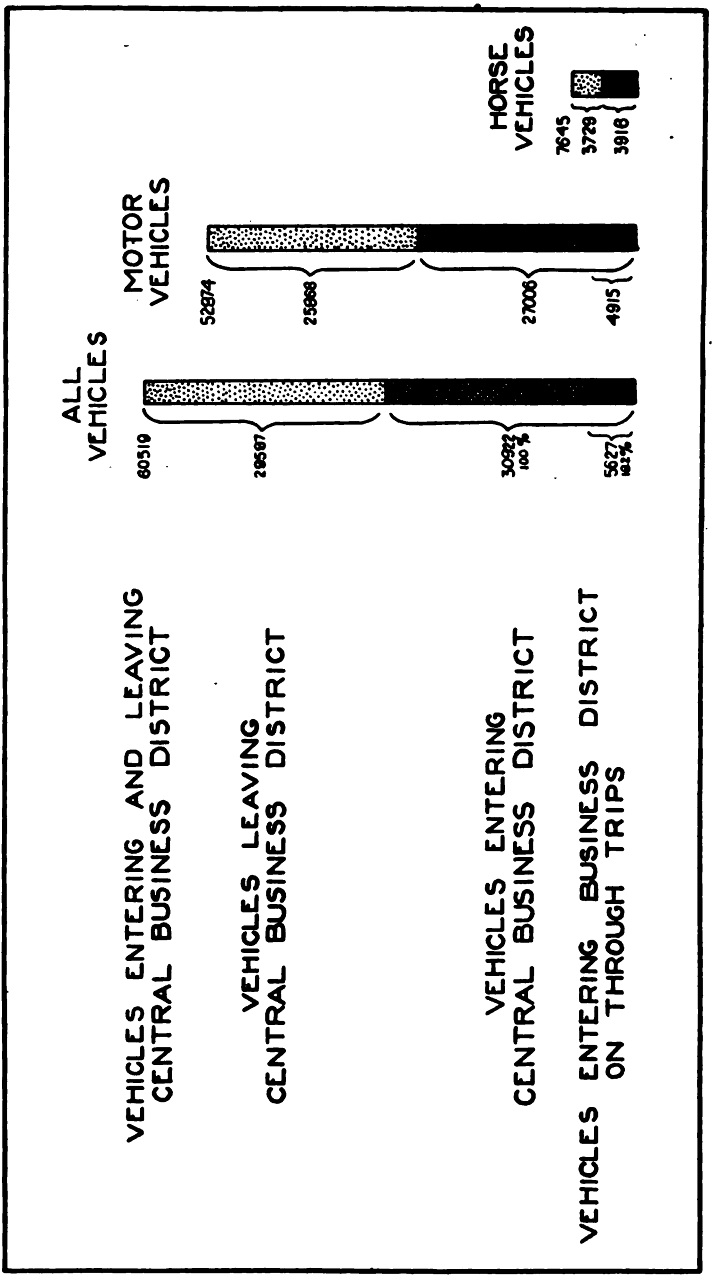


Fig. 2. Proportion of Through Traffic Entering Business District.

In transferring the record of any one appearance of a given license number from the card it was necessary only to record the counting-point number and the direction symbol in the proper time column. When these sheets were completed, a glance along any horizontal line gave a complete history of the movements of the day for that particular vehicle in so far as it passed any of the counting points.

The above described work of tabulation was carried out under the direction of Mr. Carr of the Transit Commission with the assistance of a few city employees and a large number of high-school students who were employed by the Citizens Committee through arrangement with the Board of Education.

With the record sheets above described before us, we were able to trace the movements of vehicles entering the triangle at any point in order to determine what portion of them were probably making through trips which would not have necessitated their entering the triangle at all had there been an adequate system of by-pass thoroughfares provided. It was assumed that vehicles in this class entered and passed out of the triangle within the same or consecutive 15-minute periods at such points of entrance and exit as would indicate that a through or continuous journey was being made rather than a return or loop journey. It was found that over 18 per cent. of all traffic entering the triangle was of this class. This is shown graphically in Fig. 2. It is probable that this percentage could be materially increased on account of vehicles delayed beyond the limits of two consecutive 15-minute periods while passing through, and on account of vehicles passing through the triangle and making stops for reasons which would not necessitate a trip to the triangle.

The importance of eliminating from the triangle this unessential through traffic—amounting as it does to probably 20 per cent. of the whole—will be realized when it is remembered that a very considerable portion of it consists of heavy trucking traffic. It is evident that as time goes on it will become increasingly important that a system of by-pass routes be developed in order to give this traffic an opportunity to avoid the triangle. This will have to be accomplished by the improvement, widening or extension of certain streets and the building of certain bridges. It is not the intention of the writer to discuss at this time the various recommendations of the Citizens Committee on City Plan as to the development of the major street system, which recommendations appear in its recently published report. Fig. 3 showing a system of routes by-passing the triangle, is taken from that report.

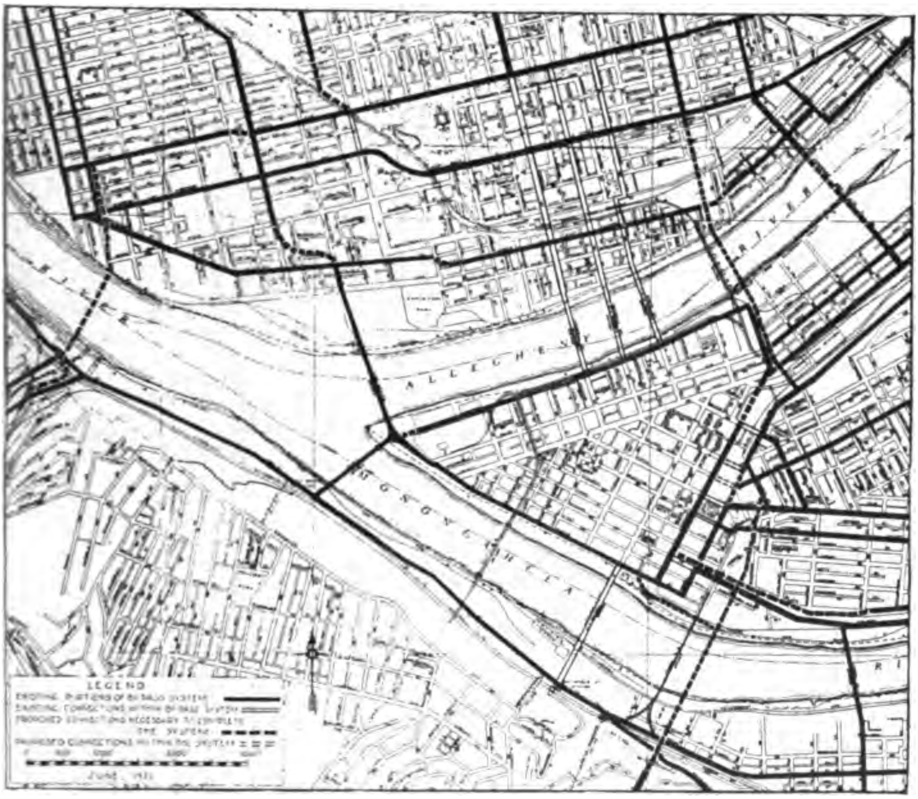


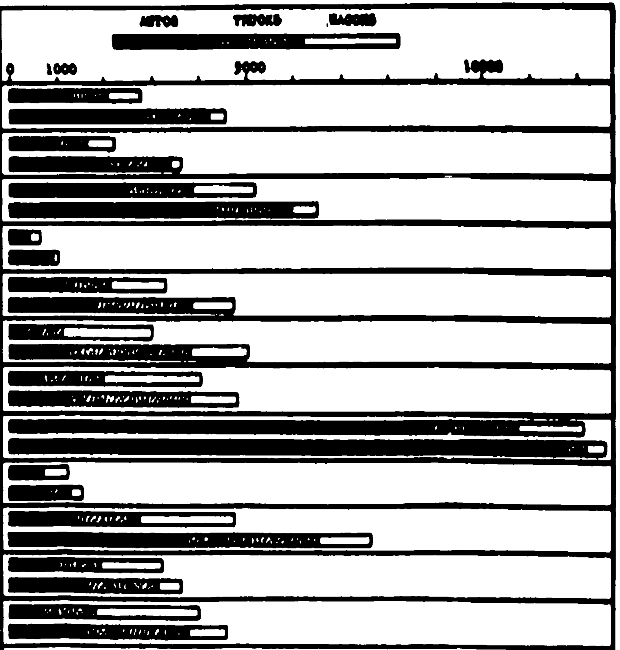
Fig. 3. System of Major Streets to Avoid Triangle.

As an indication of the necessity of bestirring ourselves and taking thought for the morrow as to what we are going to do with the rapidly increasing traffic which is pouring into the

COMPARISON OF TRAFFIC PASSING ENTRANCES TO TRIANGLE IN 1917 AND IN 1920.

ENTRANCES TO TRIANGLE	July 2nd, 1917 7 A.M. to 6:15 P.M.*				Oct. 20th, 1920 7 A.M. to 6:15 P.M.			
	Autos	Trucks	Wagons	Totals	Autos	Trucks	Wagons	Totals
Point Bridge	1328	730	722	2780	2647	1553	371	4571
Manchester Bridge	966	676	580	2222	2115	1295	248	3658
16th St. Bridge	2476	1391	1352	5219	4154	1823	532	6509
7th St. Bridge	245	192	222	659	513	416	115	1044
9th St. Bridge	1106	1035	1162	3303	1784	2079	905	4768
Penn Ave.	367	741	1927	3035	1267	2553	1244	5064
Liberty Ave.	644	1335	2091	4070	1241	2586	1003	4830
Bigelow Blvd., Bedford Ave., Webster Ave.	8617	2144	1358	12119	10927	1261	421	12609
Wylie Ave.	432	281	522	1235	674	604	266	1544
5th Ave., Forbes St.	1276	1470	2037	4783	3793	2762	1104	7659
2nd Ave. (adjusted)	957	980	1315	3252	1680	1462	499	3641
Smithfield St. Bridge	725	1168	2155	4048	1621	2160	837	4618
Totals (both directions)	19139	12143	15443	48179	32416	20554	7545	60515
Percent Increase or Decrease					+69.5%	+69.3%	-51.1%	+25.6%

*Note: In 1917 count was made from 7 A.M. to 7 P.M. Figures here given are adjusted to 6:15 P.M.



INCREASE OF ABOUT 25% IN 3¼ YEARS

Fig. 4. Increase in Vehicle Traffic in 3¼ Years.

triangle district, Fig. 4 showing the amount of increase in three years, is of interest. The comparison is between the count made at the entrances to the triangle on July 2, 1917, by Mr. E. K. Morse, then Transit Commissioner, and the count made by the Citizens Committee on City Plan on Oct. 28, 1920. In order to permit of a comparison, certain adjustments have been made in the 1917 figures on account of slight differences in the location of counting points and on account of the fact that the 1917 count ended at 7 p.m. while the 1920 count ended at 6:15 p.m. The adjusted total for the vehicles passing the entrances to the triangle in both directions from 7 a.m. to 6:15 p.m. in 1917 is 48,179, while the corresponding total for 1920 is 60,515. This shows an increase of 25.6 per cent. in 3¼ years.

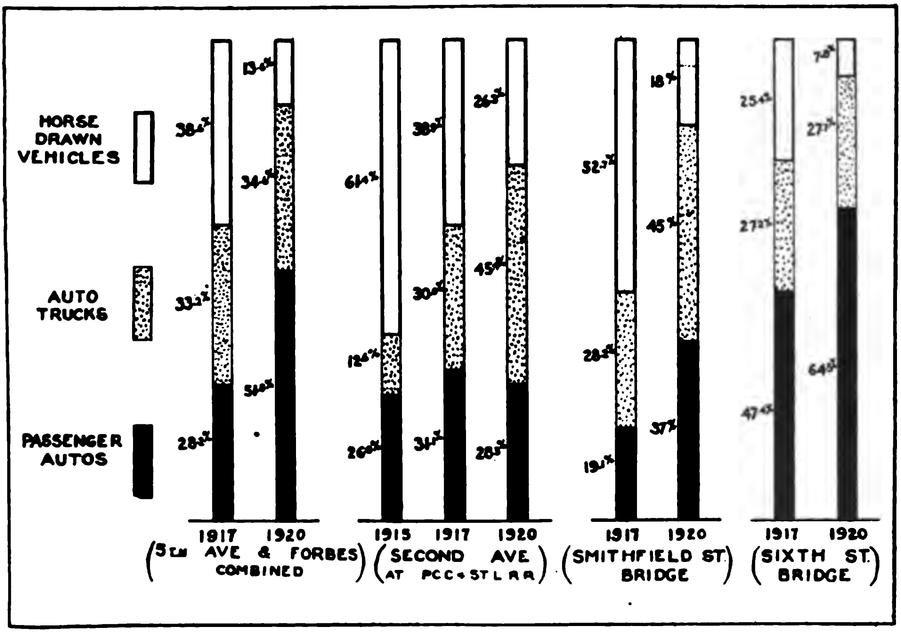


Fig. 5. Proportion of Various Types of Vehicles Entering the Triangle at Certain Points.

Predictions as to what this ratio of growth may amount to in the future are futile. There are, however, at work two potent forces which will tend toward a limitation of traffic entering the triangle, irrespective of what the increase in vehicle ownership in the city and district may become. One of these is the growing congestion in the streets of the triangle which may become so great as to cause large numbers of automobile owners to avoid entering the triangle except when absolutely necessary. The other, and the most effective, limiting agency will be the lack of parking places or even stopping places for cars within the business district. The widening of streets or the removal of street-car tracks from the surface may help in increasing the traffic capacity of the triangle, but no man has yet come forward with a feasible suggestion as to how the parking needs of the district are to be met. This is a matter which should become the subject of profound study. It cannot be left to take care of itself.

Fig. 5, showing the percentage of vehicles of different type—namely horse-drawn vehicles, passenger automobiles, and auto trucks—passing certain entrances to the triangle in 1915, 1917, and 1920, is of interest as indicating the rapid displacement of the horse. The 1915 count, covering Second Avenue only, was made by Mr. Louis P. Blum, and the percentages were worked out in his office.

One interesting analysis carried out by the Committee was for the purpose of showing what would be the effect of a hypothetical cross-town viaduct built across the eastern portion of the business district and connecting the South Side with the North Side and having eastwardly connections with certain of the streets leading into the triangle from the east. The analysis indicated that such a by-pass thoroughfare on the eastern borders of the triangle would result in diverting something over nine per cent. of the total traffic passing the entrances to the triangle.

There are possibilities of analyzing in various ways the traffic data collected during this count, but the staff of the Citizens Committee has been too limited to permit of pursuing many of these possibilities.

Fig. 6 shows graphically the amount of traffic passing in both directions over the thoroughfares included in the count. The relative amount of traffic is indicated by the width of the lines.

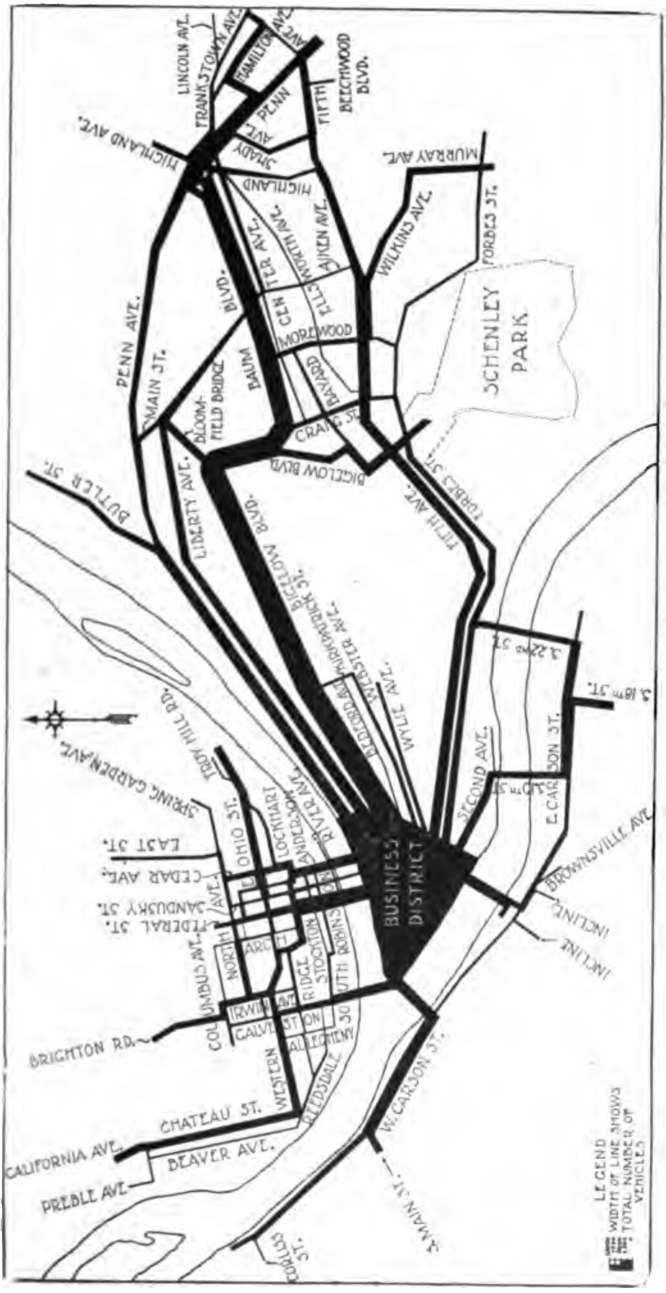


Fig. 6. Comparative Density of Traffic on Various Streets.

STREETS AS TRAFFIC CARRIERS

Closely allied with the quantitative study of traffic is the study of traffic capacity of the streets. It may not be out of place to make a few general remarks upon this subject.

For many years it has been the custom of the best architects when designing a residence to lay out on the plans the position of the various pieces of furniture within each room and to arrange each room so that each piece of furniture would be properly accommodated; in other words, to adapt the space within the building to the uses to which the space is to be put. To-day a good architect will build the house to fit the furniture. It has taken engineers a long time to realize that in designing a street. a plan should be worked out by the designer to show how the space within that street is to be utilized, or that there should be a relationship between the dimensions of the street and the objects which are to occupy it. The width of the roadway was generally determined without regard to the position or arrangement of the vehicles upon it. It was apparently assumed that to add a percentage to the width of the roadway would add a like percentage to its capacity or value.

For example, there was for years in the City of St. Louis a well recognized though unofficial rule that the sidewalks should occupy 40 per cent. of the width of a street and the roadway 60 per cent. According to this rule a 60-foot street would have a roadway of 36 feet, and a 70-foot street a roadway of 42 feet. Apparently it did not occur to the engineers responsible for this rule that the 42-foot roadway could accommodate no more traffic than the 36-foot roadway and therefore was no better than the latter though more expensive to build and to maintain.

Engineers have apparently been slow to realize that the real measure of a street's utility is the number of vehicles which can safely and comfortably be passed over that street at the rate of speed which is proper for the particular kind of traffic which it is intended to carry. They have been slow to acquire the habit of thinking of roadway widths in terms of the number of lines of travel rather than in terms of feet.

Although it is easy to see that the capacity of a street can be measured by the number of vehicles which can move upon it simultaneously, it is not so easy to decide how much width should be allotted to each vehicle. The fact is that this proper width will vary somewhat according to the nature and speed of the traffic

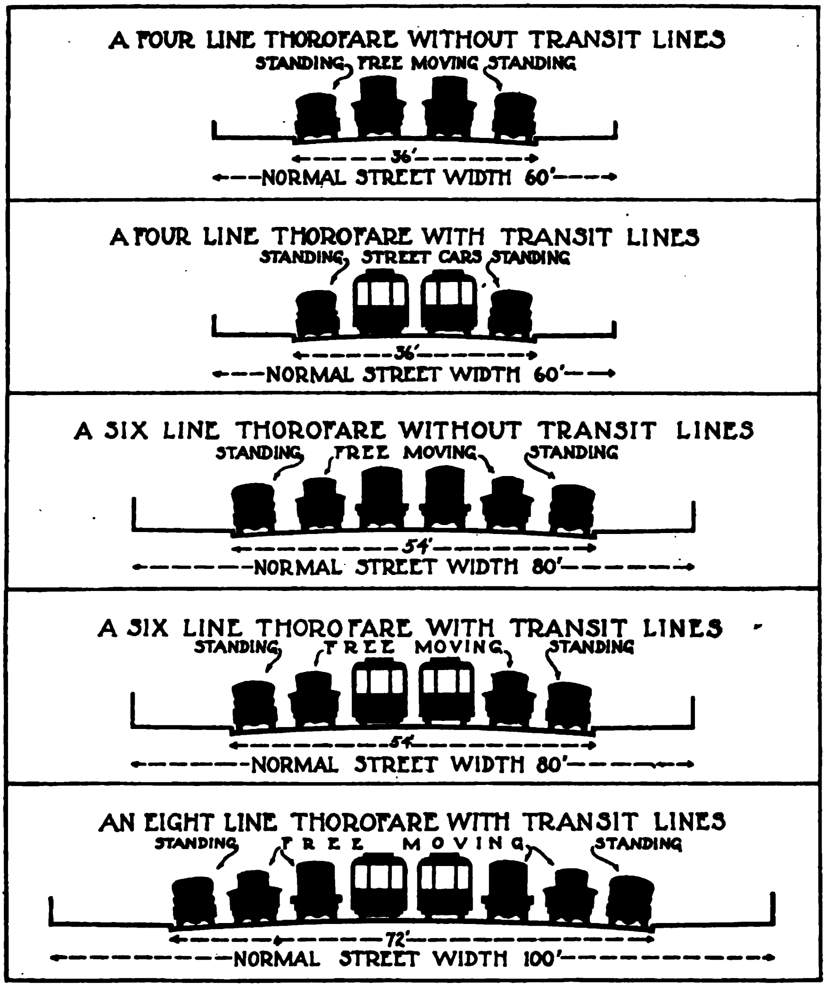


Fig. 7. Proposed Roadway Widths.

which the street is intended to accommodate. In former years it was generally assumed that eight feet was a proper width for each line of vehicles, but at present it is generally believed that this width is insufficient to permit of comfortable driving at a reasonable rate of speed. Nine feet is now generally considered to be the minimum width which should be provided for each line of moving vehicles. For high-speed thoroughfares 10 feet would be a better width. If it is expected that the space along the curbs will be used by standing vehicles and will never be used by vehicles moving at a considerable rate of speed, an allowance of eight feet for these outer strips will be sufficient; but, as it is only in certain limited localities that it can be assumed that these outer strips will not be used by vehicles moving at the normal speed, it would be better, wherever possible, to allow the full nine feet to each line. In making its recommendations the Citizens Committee has adopted roadway widths as indicated in Fig. 7.

The failure on the part of engineers to give proper thought to the way in which the space in a street is to be used, frequently results either in a waste of money, an impairment of safety, or a constriction of capacity, or in all three of these. Frequently a few feet of roadway more or less, or a different arrangement of street-car tracks, would save the day. Take, for example, a hypothetical case of a roadway 45 feet wide with two street car tracks in the middle (Fig 8, Case A). It is too narrow to accommodate safely three lines of vehicles in each direction, even if one of them is stationary. It is no better as a thoroughfare than if it had a roadway but 36 feet wide. Again, take the case of a street with a 36-foot roadway and a single street-car track placed in the middle (Fig. 8, Case B). As the direction of the street-cars is necessarily contrary to that of one of the two lanes of travel which must be partially upon the track, the character of the street as a four-line thoroughfare is destroyed and there is in addition a serious element of danger added. Again, take the hypothetical case of a long bridge which is, we will say, a link in a boulevard system which is expected to have a very heavy Sunday or evening traffic of equal intensity in each direction (Fig. 8, Case C). The bridge has a roadway of, say, 30 feet. This is too narrow for more than three vehicles to move abreast with safety. As the

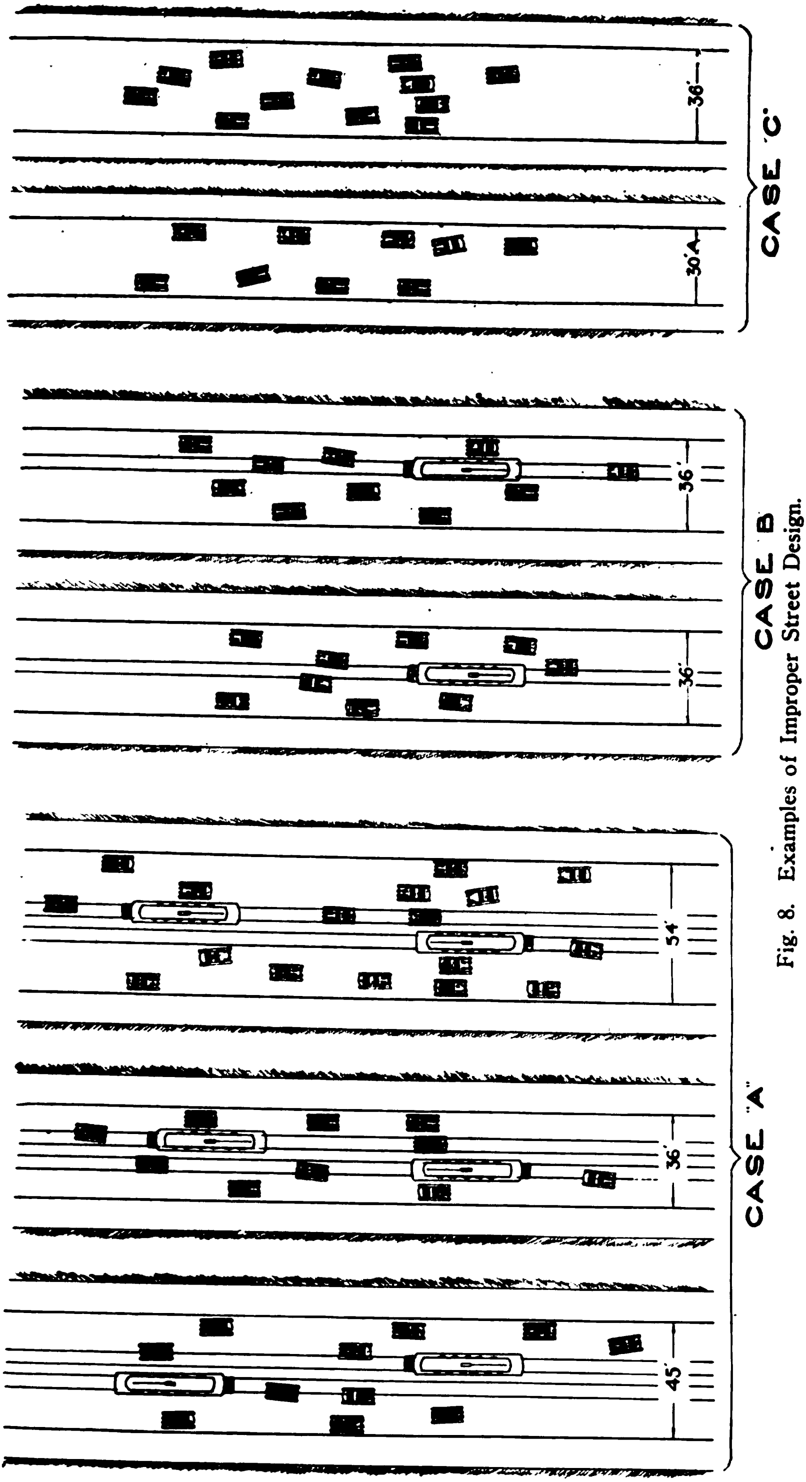


Fig. 8. Examples of Improper Street Design.

traffic is about equal in each direction, there will be a constant scramble on the part of drivers moving in opposite directions to make use of that odd line of travel, resulting in a very definite element of danger, as well as in irritation and inconvenience to the users of the boulevard. In this hypothetical case the addition of six feet to the roadway would have saved the day by permitting of two freely moving lines of vehicles in each direction. These are only typical illustrations of errors in street design such as have been and are still being made in every city in the country.

In considering the proper design of streets to insure a full measure of traffic capacity, the matter of the proper regulation of traffic within those streets should not be overlooked. The full possibilities of traffic control as a method of increasing the capacity of very congested thoroughfares have not yet been developed. For example, only a few experiments have been made as yet in the demarcation of lines of travel by visible means in order to prevent vehicles from using a much greater portion of the roadway than necessary, except when passing more slowly moving vehicles. There would seem to be some promise in this idea, and it is certainly worthy of further experimentation.

The whole complicated problem of the rapidly increasing street traffic of our cities is fundamentally the problem of the engineer. It is up to him to use his imagination and ingenuity to the end that very serious conditions in the future shall be avoided.

DISCUSSION

Mr. John A. Ferguson:* I am very much interested in this paper. For years, ever since there has been so much agitation about the traffic on our down-town triangle streets, an idea has been gaining headway in my thoughts. This is the first time I have ventured to mention it in a public way. It seems to me to be an appropriate point to raise in the discussion of this paper. In the work of the City Planning Commission the proposal has been made to limit the height of buildings to 10 stories; the reason being given that the capacity of the buildings to house people should have a not too overwhelming ratio to the capacity of the streets to bear the traffic that would be occasioned by the activities of the people in the buildings.

Among the plans that have been advanced for the solution of this problem is one involving a subway in the down-town district, leading by surface lines to the outer districts. These subways would be below possible flood levels and the foundations in many cases below permanent river levels. They would be built under streets, necessitating underpinning adjoining buildings. This type of structure is enormously expensive. Many miles of viaduct above ground, made of permanent construction and so filled that street noises would be no greater than at present, can be built for the cost of one mile of subway. As a practical method of producing the greatest relief for the money we have to spend, I am fully convinced that the wisest solution of our traffic problem as far as vehicles and pedestrians are concerned is to take the traffic off the higher levels of the surrounding hills, crossing the rivers at the levels desired by the War Department and traversing the upper deck of a double-decked town. Two streets, one above the other, may be built all over the lower triangle for the price of one inadequate subway. By this means we would have all freight, streets-cars and like traffic on the lower deck, using the present street levels for this. All rapidly moving vehicles and pedestrian traffic would move on the upper level.

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*Secretary-Engineer, Pittsburgh Building Code Committee, Pittsburgh.

If, at first, building owners are apt to stand aghast at this program let them consider its benefits before they condemn it utterly or blast it as only a fanciful dream. Almost every building of any magnitude in the city to-day has a basement and a sub-basement—some of them two or three complete stories below the ground level. These stories are now excavated and necessarily made proof against inflow of ground flood waters at tremendous expense. Even the cost of flood insurance and flood pumps may be added to the ledger favoring the double-decker plan.

Most department stores now have show-windows on two floor levels so that the question of the show-window is not very difficult.

Let us count the cost of rejecting the double-decked street plan. Without it property owners will be subjected to periodical and uncertain street widening. Without the double-decked plan and with a subway plan we will have a single improvement of doubtful efficiency costing just as much as the whole double-decked street plan would cost.

MR. LOUIS P. BLUM, *Chairman*:* In Fig. 5, showing percentage of horse-drawn vehicles, please note the proportion of horse-drawn vehicles as shown by these three careful counts—61 per cent. in 1915; 39 per cent. in 1917; and 26 per cent. in 1920. The same diminution of horse-drawn traffic is seen by comparison of census figures at three other principal gateways of the city—the Sixth Street bridge, The Smithfield Street bridge, and Fifth Avenue and Forbes Street; the Sixth Street bridge traffic going down to eight per cent. The experience of other cities is undoubtedly similar.

The following figures are extracted from the report of the Bureau of Highways of Philadelphia for the year 1920.

Highways of Philadelphia for the year 1920	Per cent. horse drawn	Per cent. motor truck	Per cent. motor passenger
Green St. at School Lane	5	38	57
Broad St. at Filbert St	3	18 to 22	75 to 79
Market St., Eleventh St. to Twelfth St	5	30	65
Market St. at Thirty-Second St	15	35	50
Bensalem Pike (Lincoln Highway)	1	20 to 25	74 to 79
Boulevard, Second St. to Fifth St. (Lincoln Highway)	1½	15 to 23	73 to 84

Note:—Market Street is in the center of the railroad freight district.

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*Blum, Weldin & Co., Pittsburgh.

I wonder if a study of these figures would make the conclusion which I have reached seem unreasonable. It seems to me that the next great reform in traffic conditions in the central triangle of Pittsburgh is the elimination of horse-drawn vehicles. To the few people to whom I have made that suggestion it has seemed quite revolutionary. These figures above, however, seem to show that by natural processes the horse-drawn vehicle is being reduced to such small proportions that the elimination of the few remaining horses from the central triangle should entail no great hardship. Any of us who have watched the traffic in our downtown streets traveling at 10 to 15 miles an hour will note how much such traffic is retarded by the few horse-drawn vehicles traveling at two to four miles an hour. The carrying capacity of our streets is certainly decreased more by these few slow-moving vehicles than by any other single factor.

Please note that I am not suggesting that we eliminate the horse-drawn vehicle altogether. There are undoubtedly proper and useful functions for the horse-drawn vehicle in the traffic of to-day. They are largely concerned with retail delivery, but retail delivery is a small factor in the down-town business of Pittsburgh, however important it may be in the outlying districts. Even in retail delivery, development is constantly toward motor-driven vehicles. Discussing the matter with the manager of one of our large department stores recently, he stated that their rather intensive study showed that for a certain area of Pittsburgh, it was cheaper to deliver by horse-drawn vehicles than by motor-driven vehicles; but that the motor-driven vehicle was an absolute necessity for districts farther removed from the city. The expense of maintaining the two organizations, caused this department store to change its entire equipment to motor-driven vehicles. This seems to me significant of the times.

Another objection which has been made to the elimination of horse-drawn vehicles is that in certain kinds of construction work it is absolutely necessary to have horses and wagons. While this has been true in the past, recent developments point to the increased use of motor trucks. In the past two construction seasons, in our own experience I have found that horse-drawn vehicles have been used on only two out of 10 projects. The other eight have been carried out entirely with motor-driven equipment.

The speaker of the evening called attention to a matter that has often occurred to me—the permanent character of our streets as compared with the ever changing character of the traffic upon them. The central triangle of Pittsburgh was laid out about 1780. Up to about 1900 there were no changes whatever in the streets as laid out in the original Wood plan of Pittsburgh; and it has only been since that time that certain changes have been made and that such rather radical changes as those of the Citizens Committee on City Plan could even command consideration. If such changes are made, they mean expenditures of many millions of dollars to adjust the plan of 1780 to fit present traffic conditions. This illustrates the importance of proper projection of new territory to meet not only present conditions, but future development as far as such development can be foreseen. Of course it would have been impossible for those who projected the streets of 1780 to conceive of the Pittsburgh of to-day, and yet we of to-day must do the very best we can to forecast the traffic conditions of at least the next 25 years.

MR. S. W. BLACK:[*] I would like to ask what street the by-pass would take over to the eastern part of the triangle and where it could land.

MR. WINTERS HAYDOCK: This is indicated in the Committee's report. A possible by-pass route between the South Side and the North Side is suggested as including the proposed bridge from the Liberty tunnels, and an approach to that bridge following in general the route of Tunnel Street and leading into an extension of Ross Street cut through into Bigelow Boulevard; thence following Bigelow Boulevard to a new bridge over the Allegheny River at Eleventh Street or at Twelfth Street, and leading to East Ohio Street, in line with East Street.

DR. C. S. PALMER:[†] I did not realize how much ignorance it is possible for a man to accumulate, and I would like to ask whether it might be possible to have this Citizens Committee report distributed to members of this Society.

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[*] President, Samuel W. Black & Co., Pittsburgh.
[†] Consulting Chemical Engineer, Pittsburgh.

I wish to emphasize the remarks of the Chairman regarding the elimination of the horse. There is another reason why the horse should be eliminated from civilization in cities. The droppings of the horse are inevitably carried by the wind and I think it is no jest that several of the western cities have passed ordinances that after a certain date horses shall be eliminated from certain parts of the city. That was done in Denver. Because a horse is a horse and because our grandfathers used horses and it was all right in those days, we put up with it. It is interesting to note that Providence is eliminating the horse by means of the automobile.

Of course, along with the automobile have come good roads, and the increase of the price of gasoline. I notice in one of the evening papers an alarmist says there is going to be a fuel famine in the country and that will result in an enormous increase in the price of gasoline and decrease in the number of automobiles. Speaking as a chemist, while it is unsafe to prophesy, it is unthinkable that gasoline or a substitute will not be found. There will undoubtedly be a substitute for gasoline so that any reasonable growth of automobiles may continue.

The suggestion that we have no place to park down town is a pretty serious proposition. I don't know what would be the remedy for that. There may be places overhead or underground. The subject certainly is interesting and I would like a copy of that report if it is possible to secure it.

Mr. F. F. Espenschied:* I would like the opportunity to commend Mr. Haydock for his very instructive and interesting paper on a subject of great importance to our city.

You, Mr. Chairman, have just now expressed what I have frequently been saying in private conversations—that the noble horse is out of place in busy business thoroughfares and should be eliminated by legislation or penalty. A high license fee would accomplish the result.

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*Pittsburgh District Representative, Commercial Truck Co., Pittsburgh.

I have recently been interviewing prominent store executives and users of city transportation and one gets various views and opinions. Some horse users claim that for down-town work the horse is the only thing, and gas cars do not show sufficient increase in speed to off-set their higher operating costs. There is something in this argument since many people were carried away by the idea of the fast gas truck, particularly when horse feed was high. Real close comparative cost analyses are however the exception. I recall one horse user who simply stated that he had been using horses for thirty years and they were good enough for him. Then there is the fruit and vegetable man, the little fellow who has one horse. In the aggregate he takes a lot of space on Penn Avenue.

The number of vehicles passing per hour depends on average rate of flow. If we could maintain a low *uniform* rate it would be better and safer than a high rate punctuated with stops at every corner, as is our usual method. We start and stop a solid line of traffic so frequently that acceleration is of importance, and it is noticeable that while horses require no gear shifting they are very slow in starting and when heavily loaded the driver hesitates to move forward at all until he sees a considerable space ahead. The horse-drawn vehicle thus takes more than its just share of the street, and in addition it is longer overall—horse and wagon together—than most vehicles. As to sanitation, the horse is permitted on streets only because he was there first but he is surely a grievous offender, even worse than the noisy, smoky gas-engine against which regulations are often enforced.

There is a third form of transportation in down-town Pittsburgh, which has escaped notice or comment, but which is for many purposes the ideal street vehicle. I refer to the quiet, efficient and unobtrusive electric trucks. Their use is growing steadily in all large cities as their many advantages are becoming appreciated. Electrics offer a relief from the rising gas and oil prices, as electric power here, as elsewhere, has been decreasing in cost. Also, these vehicles accelerate rapidly and are short overall, they negotiate traffic better than the horse, or the gas car with its clutch and accelerator. Aside from helping congested traffic the operating cost of electrics per ton-mile, on city work, is much lower than that of horse or gas truck. No one knows just what mileage a horse makes and the owner often imagines that his mileage is far in excess of reality. Horse costs also are very elastic. It will not do to take feed, shoeing, and harness at nominal rates. If we could get owners to figure cost per ton-mile, including *all* costs and delays we would go a long way towards eliminating horses down town.

DR. C. S. PALMER: The electric truck is all right on the level but it is pretty hard on hills.

MR. F. F. ESPENSCHIED: I do not like to take the time of the meeting for a discussion of the merits of electric trucks but their use is growing steadily—the result of cold facts and cost records. As examples, two laundries here are practically entirely electrified. In Johnstown and Wheeling three- and five-ton electrics are working regularly, and in Butler a bakery is using light electrics on the hills. As a matter of fact, any vehicle takes more power on hills than on the level and a modern electric will climb hills that a team or a gas car cannot go up, electrics possess remarkable power but they are not high-speed, long-distance, express wagons, they are for city delivery and heavy-duty work.

MR. P. W. PRICE:* I have been listening to this talk about eliminating horses by means of the automobile and I can't help getting up to say a word for the horse. As an engineering proposition I know the automobile has the horse beaten, but personally I am fond of the horses. I am familiar with what horses did during the war and to be frank I will state that since leaving the army (I was in the Field Artillery) my regiment (the third) has been motorized and I am glad for that reason that I am not still with it.

Would say in passing that I frequently took our light 75-m. guns into places where no tractor could go. Horses are still the best means of handling light guns in difficult country. Tractors are certainly best for heavy guns.

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*Assistant Engineer, County Engineer's Office, Allegheny County, Pittsburgh.

I realize that the farmers also are largely taking to tractors and know I am talking on the losing side of the argument. Also, by the charts we have seen to-night it is evident that if the same percentage of decrease in the relative use of horse-drawn vehicles continues in the next three years as has taken place in the past three years, the horse will have been eliminated by natural processes, but I hope there will never be legislation passed in Pittsburgh that will kill the horse.

MR. WINTERS HAYDOCK: Perhaps we can keep him in the suburbs.

MR. P. W. PRICE: People delivering ice and milk have never yet been able to get away from the horse. Every morning about 3 a.m. I hear a couple of good horses trot by my house delivering milk and notice that the iceman still sticks to his team.

One or two other things occur to me. A previous speaker spoke about a double-deck proposition for the down-town streets. I think that is not altogether a pipe dream. Possibly some day Pittsburgh may come to it, but before we come to double-deck streets, might it not be possible to elevate our sidewalks in the congested business district and thereby widen our streets by almost an equal amount. This would eliminate vehicle and pedestrian traffic crossing each other at grade which is of almost equal importance with widened streets. The suggestion to build elevated sidewalks over certain alleys, and through the center of office and store buildings where necessary, to form main pedestrian routes through the business district has been made elsewhere recently and should merit the close attention of this admirable Committee on City Plan.

One other thing in line with up-to-date, main-line development. along railroads, that should some day be applied to city traffic, is the elimination of grade crossing for traffic at certain very important points on main arteries where the topography will permit, by what in railroad terms would be called a "jump over." Vehicle traffic in turning from one side of the thoroughfare to the other, against traffic in the opposite direction, takes an inclined route and crosses overhead, similar to what is done just east of East Liberty station on the Pennsylvania Railroad, where the Conemaugh Division trains deflect from and come into the main four-track system. I think there are some places in Pittsburgh where that principle can be utilized. One possible instance is where the proposed boulevard along the rivers could be at a lower grade than the bridge approaches and pass under them, thus eliminating grade crossings at these congested points. Also, other means can be thought of where the topography is such that the main traffic intersections can be separated as to grade.

Such things make interesting study for those of us who, as members of this Society, are engineers and also citizens of this great city. The need for traffic study is very evident. The paper of the evening has well expressed this need. The city and the Engineers' Society are fortunate in having these matters placed before them in such a comprehensive way. There is no subject that should interest this Society more at the present time than city planning as applied to Pittsburgh, and the matter should be continued at future meetings. The Engineer's Society of Western Pennsylvania and its individual members have in various ways shown interest and taken part in such matters in the past, but in the future they should be more active; and we, as individual citizens, should ever be ready to take our part in promoting the physical betterment of a greater city for the days to come.

MR. JOHN A. FERGUSON: There is another municipal planning problem which has a bearing on the traffic problem. I refer to the height of buildings which it is proposed to limit in order to avoid congestion of streets from too large a number of persons going to or from buildings. I am not at all in sympathy with the proposal to limit the height of buildings uniformly to 10 stories. A height of 10 stories for all buildings in the lower down-town districts, where we now have not to exceed an average of six, would hopelessly entangle the traffic situation.

Different occupancies have different intensities of occupation; that is, in a warehouse there are a very few occupants per floor area of 1000 square feet, while in office buildings there are many. In view of this fact, from the viewpoint of traffic problems, the size of buildings might logically be permitted to vary according to the width of the street and in proportion to the number of occupants of the building per unit floor area. There are additional arguments that may be advanced in support of some other than a uniform height limit for buildings but as they are not concerned with the traffic problem it would be out of place to advance them here.

MR. F. F. ESPENSCHIED: I want to ask Mr. Haydock whether he has considered the way they handle traffic in New York on Fifth Avenue. There they start and stop the whole column, I believe several miles long, at one time by means of bells and signal lights. All the traffic on the Avenue goes forward at one time; then all stops and the cross traffic has the right of way for a minute or so. It seems to work admirably. Here we seem to retain the old system by which the officer at Wood Street, say, seems to bear no relation to the cornerman at Smithfield Street. It's a series of starts and stops, often several to the block, and we all know how trying it is.

There is also the scheme, used in Massachusetts and somewhat in New York state, of a mark or line down the center of streets to keep traffic divided properly. This applies particularly on curves, on boulevards or high-speed roads. It seems to assist in avoiding accidents and directing traffic at particular points.

MR. WINTERS HAYDOCK: As far as I know, neither of these expedients has been tried in Pittsburgh. Not having been here very many years, I cannot speak authoritatively. My personal opinion is that there is a great deal of promise offered by both of them. The scheme of causing traffic to move across the intersecting streets simultaneously, would certainly result in a marked degree of acceleration of its movement; and the scheme of marking visible lines on certain streets for the guidance of traffic should be tried out, and will be very soon, I hope.

MR. C. E. LONG:* The figures showing the width of streets in relation to the number of lines of automobile traffic they will carry, indicated that there is a dividing line beyond which the increase in the width of the street is of no advantage until you reach a certain greater width. I would like to know just where that line is. Illustrations showing the number of lines of automobile traffic accommodated on streets with one track for street-cars, locate the tracks in the middle of the street. On the street with a width of 36 feet between the curbs and one track in the middle, the street-car at the time of its passing, limits the travel to three lines of traffic. If the car service has a frequent headway, the width of 27 feet would accommodate the same amount of travel as the width of 36 feet; this is three lines of traffic. Apparently the street of 36-foot width, with one car track, is used where the car service has an infrequent headway.

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*Civil Engineer, Pittsburgh.

It would be interesting to know the allowable headway of the car service on the street with one car track when the street is designed to accommodate four lines of traffic.

MR. WINTERS HAYDOCK: I will not attempt to answer this question by giving figures for the allowable headway for cars moving over a track located in the middle of the street. Instead, I will say that, in general, if your street is wide enough for four lines of vehicles and if you have a car track that carries traffic in one direction only, that track should invariably be on the side of the street to which that direction pertains. That would give you always two lines of vehicles in each direction. In case the single track is intended for traffic in both directions there is probably nothing to be done but put the car line in the middle of the street. That is to be considered an unfortunate situation. It would be very much better, wherever possible, to avoid having cars run in both directions on a track located in the roadway of a thoroughfare. Of course that must be permitted in some cases. The situation would be saved in such a case if the roadway could be widened to a five-line capacity; that is, to about 45-feet.

As to a three-line thoroughfare; that is, a street with a roadway of about 27 feet, of course the only place for the track in such a case is in the middle.

In the hypothetical case discussed in my paper it was supposed that we had a long bridge forming a link in an important boulevard system. It could therefore be assumed that the traffic passing over it would move at a considerable rate of speed and be heavy in quantity. This would then give the conditions of which I spoke, of drivers attempting, whenever possible, to make use of that no man's land in between the two well-defined lines of traffic on the sides, and it would be up to the best dodger to determine who would get the best of the deal. You can see the element of danger in such a situation. Under those conditions the community would certainly be justified in spending the additional money necessary for a wider roadway. As to safety, conditions would be improved in the case mentioned by cutting it down to a two-line thoroughfare; but it is my opinion that in designing bridge roadways or streets in general, engineers should consider carefully whether it is not desirable and whether it is not possible to provide for a four-line thoroughfare before adopting a narrower width.

MR. J. B. MANDEVILLE:* I think it important to have something brought out on which I would like discussion—that is, the question of parking along the streets. How far should a city go in marking off a portion of a street, too narrow to begin with, for parking? I have noticed it here and we have the same trouble in Butler. The main street and connecting streets are practically blockaded by parked automobiles. That is something I would like to hear discussed.

MR. WINTERS HAYDOCK: My opinion of the question of parking on streets is that we have there a very interesting problem and one that is frequently misunderstood. I do not think it is possible or desirable to prevent vehicles from stopping in front of stores in the down-town district, no matter how congested that district may become. There is no reason for having these streets open to vehicles if they cannot stop where it is necessary to do business. Therefore we must reconcile ourselves to turning over to the stationary vehicles a portion of the roadway on either side of every street and reserve for moving vehicles the portion between those two lines.

As to the question of how long a vehicle should be allowed to park there, I do not think that has anything to do with the traffic problem. This is a question of preserving the rights of the general public to use those stopping places occasionally rather than to turn them over to the early comers who want to leave their cars there all day. As far as traffic is concerned, we have to accept the fact that the two sides of the street will be blockaded against moving vehicles. We impose the limitation as to time of parking simply to let the other fellow get a chance to get in and do his business and get out and let some one else in. There is no other excuse for the limitation of parking time except to prevent the hogging of the space by individuals, but I would not wish to advocate a law that would prevent persons from parking along the side of business streets for reasonable periods.

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*Chief Engineer, T. W. Phillips Gas & Oil Co., Butler, Pa.

I am not sure that a one-hour limitation would not promote the public convenience better than our present half-hour limitation. It might even remove a certain amount of moving traffic from the streets by making it unnecessary for the automobile user who has not parked his car in an unlimited parking place to drive around the streets so often hunting a new berth in order to avoid the unwelcome red tag. How much of our traffic congestion is caused by this circulating around in a hunt for parking places we do not know, but it is probably a considerable percentage.

MR. LOUIS P. BLUM, *Chairman*: May I be permitted to call attention to an experiment now being carried on in Washington, D. C. They have had their troubles with parking also, and have lately prohibited parking in the center of some of the streets around the White House where it was formerly permitted. The commissioners of the District of Columbia have lately proposed to limit parking in front of business houses to a very small time—I think five minutes. But curiously enough, the principal objections have developed among those who were expected to be beneficiaries. Practically every man who keeps a retail store in the city of Washington, and every department store, have objected on the ground that reasonable parking time is necessary for their patrons.

The parking problem in Pittsburgh seems to me a very important one. The service a man obtains from his automobile depends very largely on his ability to store it in an accessible place. It is useless to speak of private parking places as being an answer to the problem, because they could not at the best park

MR. C. L. WOOLDRIDGE:* I have listened to the paper and its discussion with a great deal of interest and I want to say on behalf of the Citizens Committee on City Plan of Pittsburgh that if any member of the Engineers' Society of Western Pennsylvania, or guest at this meeting, wishes a copy of the major street report I will be glad to see that he gets it if he will leave his name and address with the Secretary.

MR. J. M. RICE:† I have had occasion to study the report of the Citizens Committee on City Plan of Pittsburgh and I think it contains a wonderful fund of information with which every engineer in the city of Pittsburgh and every citizen who is interested in transportation problems should be familiar.

The discussion of this evening's paper has considered some of the means of transportation. Horse-drawn vehicles are stated to be objectionable and it is proposed to prohibit their use in the down-town section of the city. However, I wonder if this would not work a hardship upon the farmer who has not reached the stage where he can afford an automobile for transporting his produce to the city, and a tractor for cultivating his farm.

This particularly applies to the truck farmer who supplies our markets from nearby farms where the time required for transportation is not overly long. If we must make provision for him, and I believe it is necessary, it suggests the desirability of removing markets from the down-town part of the city and placing them in districts closer to the homes of the people.

Another thought occurs in connection with the raising of bridges, as to whether it would not be possible to eliminate one of the bridges across the Allegheny, substituting a single bridge for the Seventh Street and Ninth Street bridges using the money thus saved for the new bridge proposed by the Citizens Committee on City Plan leading from Bigelow Boulevard to East Street on the North Side.

Anyone who reads the Citizens Committee report carefully will have to agree that such a bridge will be an important step

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*General Superintendent, Carnegie Land Co., Pittsburgh.
†Consulting Engineer, Pittsburgh.

forward in solving the traffic problem of the triangle by by-passing the Lincoln Highway traffic around the business portion of the city, and, if a substantial sum could be saved by eliminating one of the old bridges and applied to the construction of this new traffic link, it would materially help in the early realization of the recommendations of the Citizens Committee.

A MAJOR STREET PLAN FOR PITTSBURGH

By C. L. Wooldridge*

HAS PITTSBURGH PROMOTED PROGRESS?

Several years ago, a certain Pittsburgh manufacturing concern decided to build a large addition to its plant. The new works was to employ a large number of additional men. Before proceeding with any definite plans, the company followed modern practice in such matters and made an exhaustive survey to determine just what advantages the Pittsburgh district offered as compared with other cities. This survey disclosed, among other important facts, that to the average workman Pittsburgh offered the poorest living conditions of any of the cities investigated. Now, this was a Pittsburgh concern, financed by Pittsburgh capital, and officered by men who had always taken a lot of pride in Pittsburgh, and who wanted above everything else to expand their business here rather than elsewhere but when they had all the facts before them and had carefully analyzed every phase of their problem, they decided to build in another city where the new plant is operating to-day.

The sole reason which influenced this case centered around the fact that the living conditions here are such that the best type of workmen could not be attracted. Inadequate and congested housing, high rents, inadequate playgrounds and public places of recreation, a total lack of rapid transit, an overburdened trolley system and, finally, a system of narrow, crooked streets laid out mostly along the lines of least resistance over a most difficult topography, cause the thoughtful engineer to doubt seriously that "Pittsburgh promotes progress."

I am aware that I have here stated a disagreeable fact at the risk of being charged with disloyalty to my native city, but is it not better to face the situation frankly rather than blindly claim, as most Pittsburghers are inclined to do, that Pittsburgh is an ideal community in which to spend one's life?

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*General Superintendent, Carnegie Land Co., Pittsburgh.

During the last 10 years, we have seen Detroit increase its population by 113 per cent., Cleveland by 42 per cent., Baltimore by 31 per cent., while Pittsburgh comes through with a bare 10 per cent. We are, in point of population, now the ninth city with 588,000. Los Angeles, now the tenth city with a population only 13,000 less than Pittsburgh, has increased 80 per cent. in the last 10 years, while San Francisco and Buffalo, with increases of 22 per cent. and 19 per cent. respectively, will inevitably pass Pittsburgh unless a radical change is effected in the living conditions here. We have all seen the automobile industry locate in other cities with Pittsburgh never being seriously considered. For the past 25 years, we have been complacently boosting Pittsburgh as the "workshop of the world," but we have made very little real progress towards making the community a better place in which to live. Other cities have met and are meeting this problem intelligently and unless we waken up and eliminate some of our handicaps, we can only expect Pittsburgh to go backwards.

Realizing that we were not progressing as rapidly as other cities were doing, a small group of business men got together three years ago and organized the Citizens Committee on City Plan of Pittsburgh. This organization is an unofficial body of private citizens who believe that a definite and workable program of development is even more necessary for the City of Pittsburgh in its business than it is for any individual Pittsburgher in his business or profession. This Committee was organized with the sole object of producing the Pittsburgh Plan, to give Pittsburgh an orderly, scientific, comprehensive program of city-building, and to secure for its people greater comfort, safety, health, convenience, utility, and beauty in their daily lives. The Committee has no political connections and no partisan purposes.

THE SCOPE OF THE PITTSBURGH PLAN

A complete city plan may be divided under the following general heads:

1. A system of major streets or thoroughfares.
2. A transit system, including all surface, elevated, and subway trolley lines.

3. A transportation system, including all steam railroads with their passenger and freight terminals.
4. A recreation system, including parks, athletic fields and playgrounds.
5. A system of zoning.
6. A system of housing, which is sometimes omitted as a part of the general plan probably because it is a matter, controlled by private investment, which will usually develop along proper lines if the other main divisions just mentioned are provided.

The Committee does not intend to include housing in the Pittsburgh Plan.

The item of zoning has fortunately been provided for by the Zoning Enabling Act of 1919, under which the necessary ordinances have been prepared and will be administered by the official City Planning Commission, which functions through the city council. So, therefore, the work of the Committee will be confined to the first four subjects mentioned; that is, major streets, transit, transportation, and recreation.

That part of the recreation report which deals with playgrounds has been completed and published, and the sections dealing with recreation fields and parks will be completed early next year. A vast amount of data has been prepared for the use of the Subcommittees on Transit and Transportation, who should complete their work during 1922. This briefly describes the scope of the plan, with the exception of the report of the Subcommittee on Major Streets, which is now complete and is the subject of this paper. Before taking this up in detail, it is of interest to know some of the difficulties the Citizens Committee encountered before taking up actual preparation of the plan.

The most serious obstacle to immediate study was the lack of street and topographical maps of the metropolitan district. Progressive cities, Cincinnati, Baltimore, and Akron among others, have provided a basis for planning in comprehensive maps, based on precise triangulation and showing in detail topography, parks, cemeteries, public buildings, transportation lines, and other features that influence modification or extension of existing thoroughfares. Pittsburgh, however has been dilatory in this respect, although the value and necessity of such maps have long been recognized. More than 10 years ago, the City Bureau of Engineering started work upon a topographical survey. Some primary triangulation work was done and precise bench-marks were established throughout the city. The force engaged was small and was so often pressed into service on other work that not a great deal had been accomplished up to the beginning of the World War, at which time the work was stopped and has never been resumed. Since there does not exist an accurate street map showing the relative positions of the various sections of the city and their connecting thoroughfares, it is most unfortunate that an undertaking so important was never completed.

As reliable maps of this kind are essential to intelligent study of the present street plan and its possible improvement, the Committee immediately undertook to get them. Bids were taken on a complete plane-table survey of the city and the lowest price received approximated $100,000. As this was beyond our means, we compromised by employing one of the large private engineering offices to secure and co-ordinate all reliable data from the city and County Bureaus of Engineering, the United States Engineer's Office, the Flood Commission, the Transit Commission, and such private engineering offices as had available information. From this data, this concern made the following new maps, which have been used as a basis for the Pittsburgh Plan. These maps, which we have divided into three groups, are of such vital interest to every practising engineer that I will mention them in detail.

Group I, consists of three maps of the city of Pittsburgh and immediately adjacent densely populated areas, which are on the scale of one inch equals 400 feet.

1. Base map.
2. Street and road map.
3. Topographic map, with a contour interval of 20 feet.

Group II consists of eight maps of the Pittsburgh Metropolitan District, comprising most of Allegheny County and portions of adjacent counties within a reasonable distance of the city and along such important arteries as trunk-line railroads, rivers, etc., and which are on the scale of one inch equals 2000 feet.

1. Base map.
2. Street-railway map.
3. General transportation map.
4. Street and road map, with boulevards and parks.
5. Topographic map, with a contour interval of 20 feet.
6. Topographic classification map showing areas classified in colors as to topography and suitability for industrial, commercial and residential development.
7. Industrial, commercial and residential map, showing location of various kinds and classes of industrial, commercial and residential areas, together with important public properties and buildings.
8. Population map.

Group III consists of five maps of the Pittsburgh Metropolitan District, showing the utilities, and which are on the scale of one inch equals 2000 feet.

1. Water-supply map.
2. Sewerage and drainage map.
3. Gas system map.
4. Electric-power map.
5. Miscellaneous utilities map.

The cost of doing this work approximated $40,000, and, while we frankly admit that the maps are to some degree inaccurate, we believe that they to-day constitute the most complete and reliable information of the kind that there is in existence covering the Pittsburgh District. When the Committee's work is accomplished the originals of this record will be placed in the custody of the Carnegie Library of Pittsburgh or the city or county engineering offices, or possibly in the library of the Engineers' Society of Western Pennsylvania. This is a matter which will be decided at the right time.

Another very grave difficulty which the Committee encountered was a financial one. The complete Pittsburgh Plan will cost between $200,000 and $300,000 and this is being financed entirely through private subscriptions. Fortunately the community contains enough progressive concerns and individuals who have generously kept the work going because they have been convinced that it will not only benefit our people as a whole, but will actually, some day, produce definite individual financial returns. We have received individual subscriptions all the way from $100 to $10,000, and while all the money necessary has not been raised we are confident we will ultimately be successful in this regard. Altogether about three hundred individual subscriptions have been made.

REPORT ON A SYSTEM OF MAJOR STREETS

A major street plan in an arrangement of main thoroughfares, and should comprise only the main routes of travel. It differs from a minor street system in that it is used to pass from one section of the city to another, while the minor streets are purely local in their use to their immediate vicinity. These minor streets must be tributary to the major streets and as a rule they serve their purpose better if they are arranged to discourage through traffic from using them. A street placed upon the city map, or developed upon the ground, is not necessarily a thoroughfare. It can be a thoroughfare only if it is so developed as to attract and facilitate traffic. It must be adequate in width and type of paving. It cannot have excessive grades if it is properly to fulfill its function. To design a street according to its probable use is a reasonable but uncommon practice. In an intensely developed district like Pittsburgh, it is very important to differentiate between major and minor streets. The expense of constructing major streets is greater, particularly here where many main thoroughfares are narrow in width and have heavy grades. Also, it is less costly to select a limited number of streets and develop them as main thoroughfares than it is to construct all streets to carry through traffic.

In some cases it is difficult to make this selection because of confusion regarding routes of travel. Motorists seek detours to avoid congestion, bad paving or heavy grades, and frequently they think in terms of good paving rather than in directness of travel. Each favorite detour of one man becomes to him a main thoroughfare.

Because of these difficulties of selection, the Subcommittee on Major Streets has studied the subject with the utmost care before presenting its report. More than one hundred and fifty streets or portions of streets have received special consideration. These comprise 86 routes of travel of varying length and importance, which in turn include as many as five separate streets each. After these routes were selected, the Committee placed a traffic value on each street in terms as affecting its width. This information has been tabulated in the report as shown in Table I. This table shows the existing grades, street width, and number of car tracks, in addition to the proposed lines of traffic, which in this particular case, result in a roadway width of 54 feet, leaving two 13-foot sidewalks.

TABLE I. PROPOSED CHANGES IN PITTSBURGH STREETS

		Existing			Proposed	
	Grade per cent. Between	Street width feet	Number of car tracks	Lines of traffic	Road-way width feet	Normal street width feet
Forbes Street (Including Diamond Street from Ross Street to Forbes Street)	....	....	....	6	54	80
Diamond Street to Magee Street	0 and 5	50	2	6	54	80
Magee Street to Pride Street	0 - 5	80	2	6	54	80
Pride Street to Maurice Street	0 - 5	60	2	6	54	80
Maurice Street to Craft Avenue	5 - 7½	60	2	6	54	80
Craft Avenue to 500 ft. west of Bigelow Boulevard	0 - 5	60	2	6	54	80
Above Point to Bellefield Avenue	0 - 5	80	2	6	54	80
Bellefield Avenue to Woodlawn Avenue	0 - 5	60	2	6	54	80
Woodlawn Avenue to Darlington Road	5 - 7½	60	2	6	54	80
Darlington Road to Murdoch Street	0 - 5	60	2	6	54	80
Murdoch Street to Wightman Street	5 - 7½	60	2	6	54	80
Wightman Street to 150 ft. east of Beechwood Boulevard	0 - 5	60	2	6	54	80
Above Point to Dallas Avenue	5 - 7½	60	2	6	54	80
Dallas Avenue to 200 ft. east of Homewood Cemetery	0 - 5	60	2	6	54	80
Above Point for 200ft. eastward	5 - 7½	60	2	6	54	80
Above Point to city line	0 - 5	60	2	6	54	80

One of the interesting studies developed during the work illustrates very graphically the result of haphazard planning, or to be more accurate, a lack of planning.

The map in Fig. 1 shows all of the streets of Pittsburgh which are 60 feet or more in width. On this, the river bridges are shown regardless of width, although many of them are inadequate in this respect. It will be noted that on the entire North Side and South Side there is to-day not one thorough-

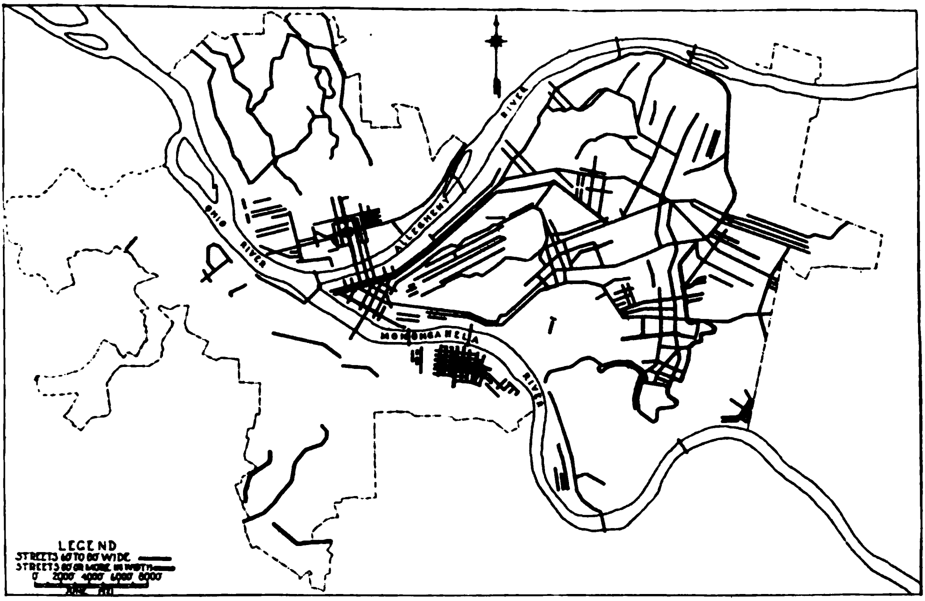

Fig. 1. Map of Pittsburgh Streets Sixty or More Feet in Width.

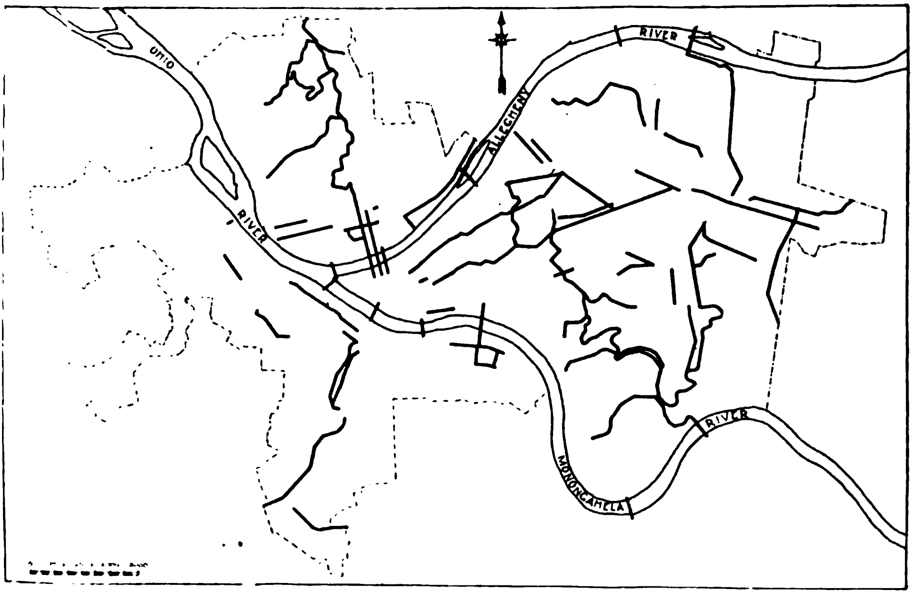

Fig. 2. Pittsburgh Streets of Adequate Width.

fare entering the city, which is not throttled down, for no apparent good reason except lack of planning, to less than 60 feet. In the central portion of the city there are but four thoroughfares leading eastwardly which are 60 feet or more in width. These are Penn Avenue, Liberty Avenue, Bigelow Boulevard and Fifth Avenue. I think this is one of the most astonishing facts disclosed by our studies, and the information is probably new to most of us.

While Penn Avenue is included among these four streets 60 feet and over, it really should be eliminated because from Seventeenth Street to Twenty-Fourth Street, it is occupied by wholesale produce merchants who have wagons and trucks standing at the curb continuously throughout the day. Penn Avenue for a stretch of seven blocks can only be considered as having a capacity of two lines of traffic, so that really we have entering the entire city but three routes which are continuously 60 feet or more in width.

The map in Fig. 2 shows the existing portions of the proposed major street plan in which streets are now as wide as

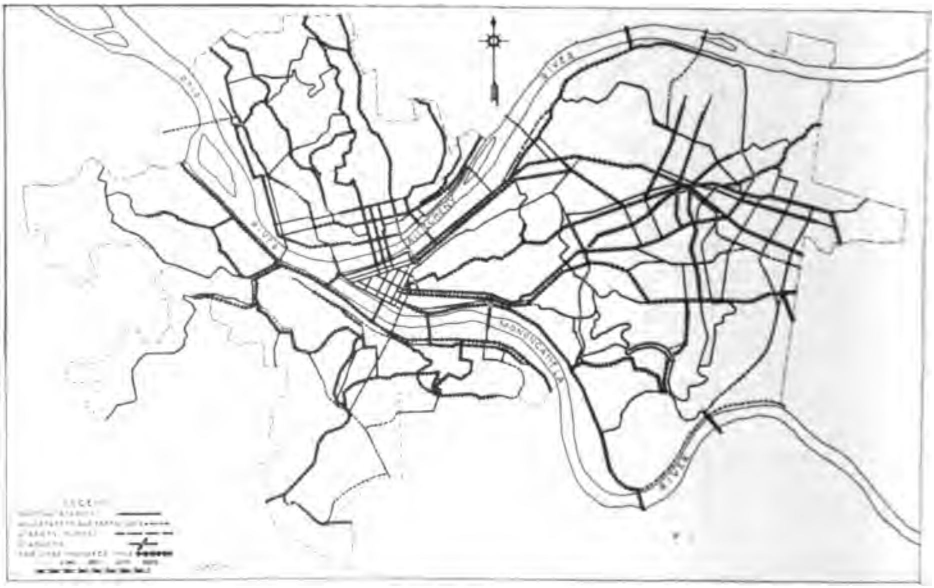

Fig. 3. Pittsburgh Street-Car Lines on Proposed Major Streets.

the Committee recommends. From this map we have omitted all minor streets, all proposed new streets and extensions, and all major streets which are recommended to be widened. The inadequacy of the circulation system and the lack of continuous thoroughfares of uniform capacity are strikingly indicated.

The inadequacy of our major streets as to traffic capacity is further indicated by the fact that most of them are occupied by transit lines (See Fig. 3). Normally in Pittsburgh, a 60-foot street has a roadway capacity of four lines of traffic and is 36 feet between curbs. If vehicles stand at the curb, and the tracks are congested or blockaded with street-cars, the street is then impassable. In other words, a four-line roadway for transit lines and vehicles standing at the curb does not assure a free moving line of traffic in either direction. To assure the latter, it is obviously necessary either to remove the transit lines or to widen the roadway by two additional lines of traffic, or 18 feet.

Fig. 4 shows the complete major street plan, in which, for the sake of simplicity, the minor streets are omitted; but this plan, superimposed over the complete existing street system will be illustrated later. It is impossible in a paper of this length to describe the plan in detail. I will state, however, that the Committee took up and studied every possible route, block by block, and the widths recommended take into consideration not only the traffic which that particular route will have to bear, but also to just what extent it is relieved from traffic by parallel alternate routes. Due consideration was given to the question of cost in the proposed widenings and new streets, and the recommendations are made only after the most careful study of every phase of the problem. It should be forcibly emphasized that the Committee does not claim that it is economically possible to undertake all the suggested improvements at this time or that when undertaken, it will be practicable in all cases to secure street widths which the city should have. Nevertheless, it is realized that, in time, some of the difficulties may seem less serious than they now appear and that increasing population and wealth (and therefore increased capacity to pay) will tend to justify costs. Therefore, in its report, the Committee has indicated those minimum roadway widths for each thoroughfare which in its

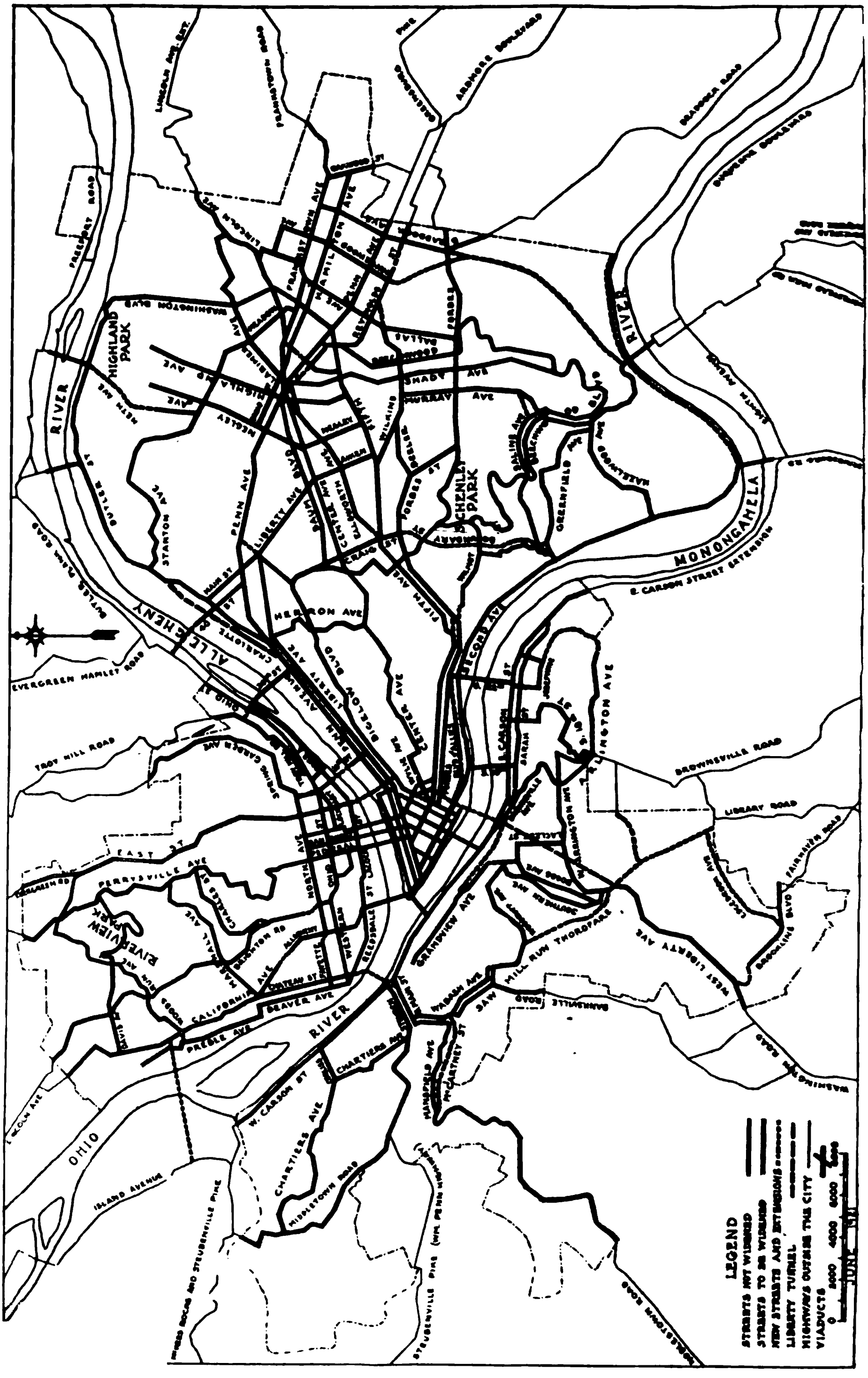

Fig. 4. Proposed Major Streets for Pittsburgh.

judgment show the importance and value of that street as a traffic artery and represent what the city should strive to secure if it is economically possible. A summary of changes recommended is shown in Table II.

TABLE II. PROPOSED CHANGES IN PITTSBURGH STREETS

Districts	Widenings		New streets	
	Number of streets	Mileage	Number of streets	Mileage
Central and East End District..	54	57.78	20	12.82
South Side	23	26.00	9	8.40
North Side	31	24.22	7	1.13
Totals........................	108	108.00	36	22.35

TABLE III. PROPOSED STREET IMPROVEMENT IN VARIOUS CITIES

	Number of streets to be widened	Miles of widening	Number of new streets	Miles of new streets
Pittsburgh..................	108	108	36	22
Cleveland	98	190	37	23
St. Louis..................	50	69	21	17
Detroit	119	284	87	21

Table III shows how the problem in Pittsburgh compares in size with other cities where city plans are being made.

METROPOLITAN DISTRICT ROUTES

In general, the recommendations are divided into two classes, the routes of general circulation within the city itself, and the metropolitan district routes. These metropolitan district routes are of special significance because they lead out beyond the city into the county highways, many of them passing through well-developed and populous suburbs. Such thoroughfares are logically a part of the thoroughfare system of the metropolitan district and they cannot be considered solely from the city's standpoint.

Thoroughfares which terminate inside the city may have to take care of great increases in traffic due to a more intensive use of the land in the areas which they serve. There is, however, a limit to such use and, therefore, a limit to the traffic such thoroughfares may be called upon to carry. On the other hand, the thoroughfares which lead out into the suburbs and rural districts may be expected to have a greater, and perhaps an unlimited, increase of traffic imposed upon them, and for this reason in the report it will be found that the street system is divided as I have indicated; that is, 17 metropolitan district routes and 64 additional routes for general circulation within the city proper.

UNDEVELOPED AREAS

In Fig. 5 the map shows the major street system superimposed on the existing system of minor streets. In this connection, it is of interest to call your attention to a number of undeveloped and practically unpopulated areas which exist, some within the city limits and some very close to the city. For instance, take the area marked *C*. This is a great tract of undeveloped land which is capable of housing at least 50,000 people, within 20 minutes' street-car ride of the court-house and a somewhat shorter period if rapid transit should ever be available. These areas, which in themselves constitute ideal home-building sites, have not been developed as such, solely because a street system and a system of transit have not been worked out connecting them with the business centers. As a matter of fact, this short-sighted policy has resulted in our forcing home-seekers to locate in congested districts along existing lines of transit and transportation, and we have actually forced out of the city, into the surrounding towns, a population which approximates the population of the city proper. A good example of this is to be found in the section marked *A*, and known as Brookline. This district is accessible only at its outer end, at the end of West Liberty Avenue, and here an intensive development has taken place; while at the end much nearer the city, and comprising just as good building sites, is an almost wholly unpopulated section because its only street, Pioneer Avenue, is located on impossible grades and has never been improved.

Fig. 6 gives some idea of the way the population has avoided these inaccessible areas. Each dot represents 100 persons. It will be noticed that there are, within reasonable distance of the city, many areas which are sparsely populated and which show in sharp contrast to densely populated districts where the

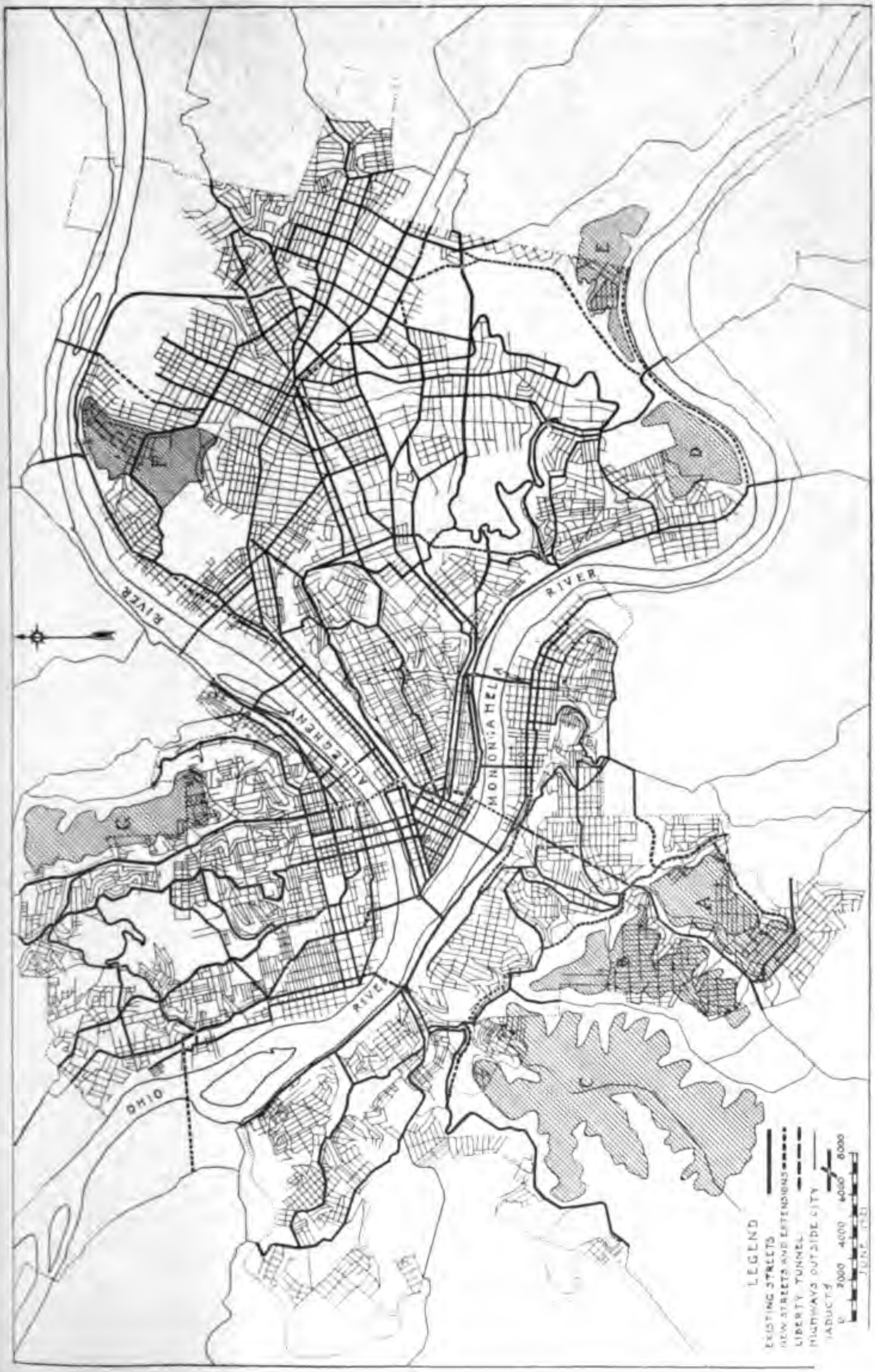

Fig. 5. Combined System of Major and Minor Streets.

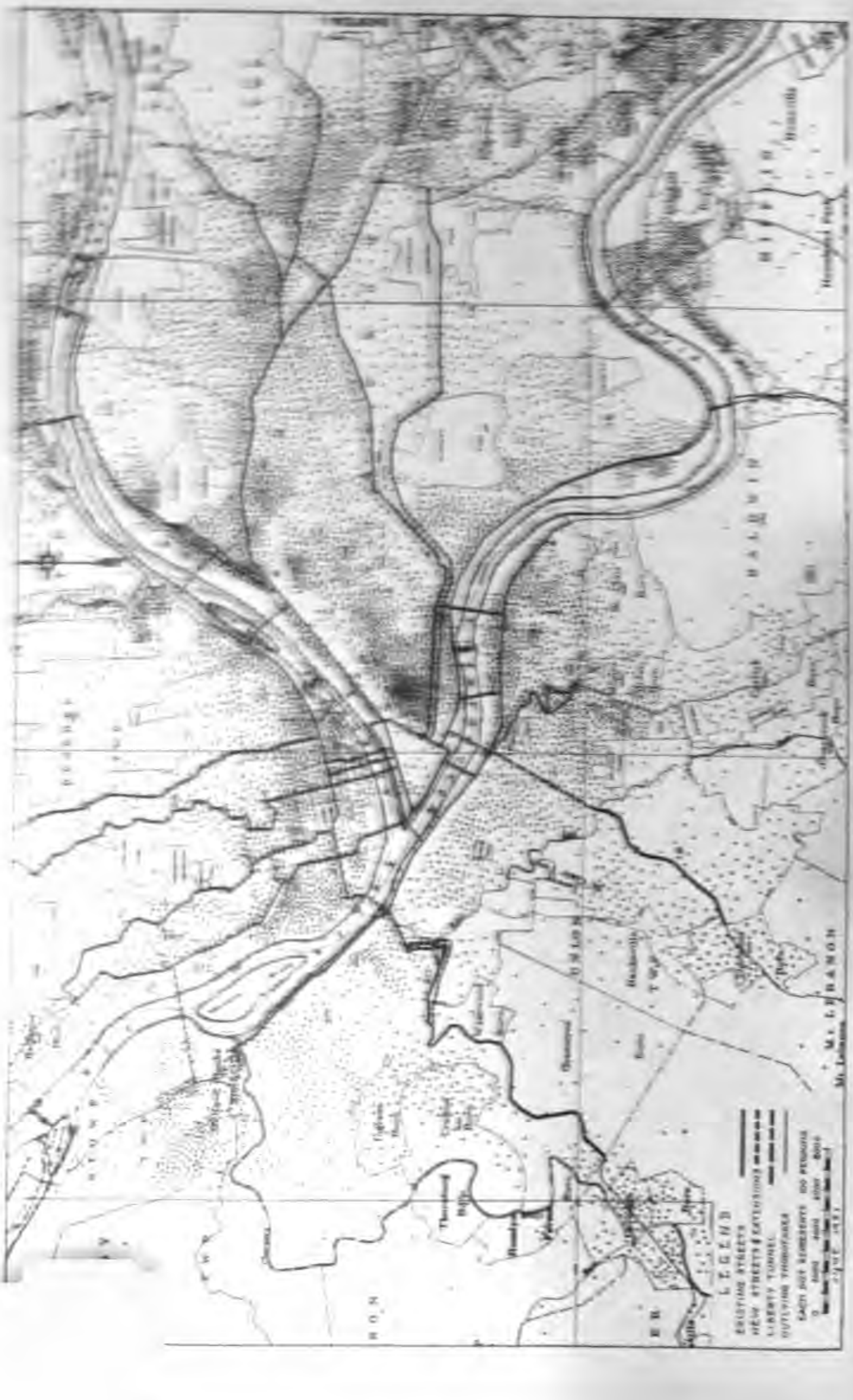

Fig. 6. Distribution of Population in Pittsburgh.

people have followed the lines of easy street development and systems of transit and transportation, although much farther away from their place of business—in many cases demonstrating that the lack of a comprehensive plan has actually resulted in our building up the outlying districts at the expense of the city proper. The report on major streets does not specifically recommend the best method for opening up these undeveloped tracts, but a chapter in the report is devoted to their consideration and several alternate plans for making them accessible are suggested. Fig. 6 shows the 17 major routes leading into metropolitan district thoroughfares.

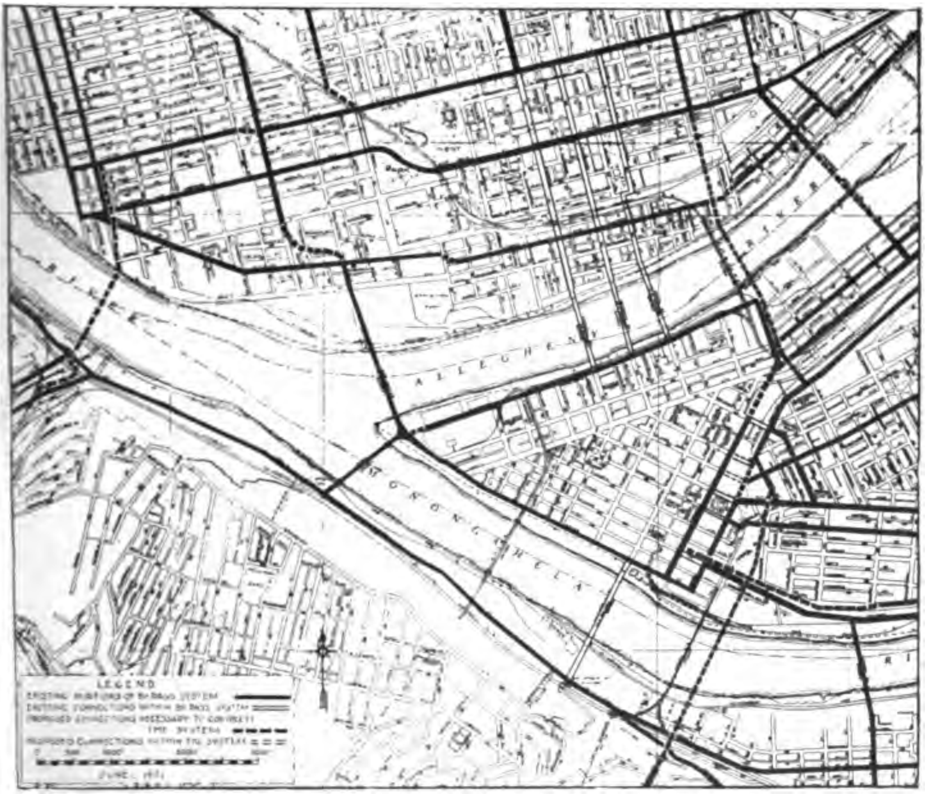

Fig. 7. Arrangement of Major Streets To Divert Traffic from Business Section.

THE TRIANGLE

Recently Mr. Winters Haydock read a paper on "The Traffic Count" as outlined in the report of the Committee on Major Streets, and made special reference to the intolerable traffic conditions in the triangle, or that district bounded by the two rivers, and Grant Street. This analysis shows that at least 10 per cent. of the traffic in the triangle goes there only because it cannot reach its destination beyond this area in any other way.

Fig. 7 shows a system of by-pass thoroughfares which has been carefully worked out as a part of the plan. I believe it is inevitable that the city will be forced to do at least a portion of this work in the very near future.

This report on the major street system will have to be revised at a later time to meet the conditions developed by the reports of the Committee on Transit and Transportation, but such revisions should not radically change its general recommendations.

CONCLUSION

In closing, I wish to make some reference to the personnel of the Committee issuing this report.

Mr. James D. Hailman, the Chairman, is a graduate of Rensselaer Polytechnic Institute, and a man who devotes his whole time gratuitously to civic affairs.

Messrs. George S. Davison, S. L. Tone, N. S. Sprague, and C. L. Wooldridge are engineers. The other two members of the Committee are Mr. L. W. Monteverde, one of the foremost real-estate authorities in this district, and Mr. Charles D. Armstrong. the head of a large manufacturing concern. In mentioning these names, the point I wish to emphasize is that this is distinctly an engineers' report.

In arriving at the result presented, the Committee adopted a method of procedure different from that customarily followed and which is perhaps unique in city planning work. Usually an expert is engaged to make the necessary investigation and prepare the report, which is then only scrutinized more or less carefully by those who have engaged him. In the present instance, the subcommittee above mentioned has itself investigated every problem and prepared the report directly. They have been assisted by Harland Bartholomew, a noted town planner, as consulting engineer, Frederick Bigger, town planner, and Winters Haydock, engineer.

We have all formerly seen similar reports made and forgotten without accomplishing their object, and the question naturally occurs as to how we are going to persuade city authorities that our recommendations should be executed. We propose to do this solely by wide publicity and education, which method has been successful in Chicago, St. Louis, and other cities. This publicity will be obtained in the daily papers, and through the publication of our own magazine, which already has a considerable circulation; and we are now organizing a group of public speakers who will be available for every occasion. We are preparing a text-book, which the Board of Education has agreed to use in the public schools, and this, we anticipate, will be especially valuable, as much of the plan will necessarily have to be accomplished by the coming generation.

In general, no opportunity will be neglected to create a healthy public demand for the items recommended, and we are now certain that the result we are striving for is ultimately assured.

DISCUSSION

Mr. P. W. Price:* I was very much interested in this paper. I think it is a matter that should engage the attention and co-operative effort of this Society and all engineers who are also citizens of Pittsburgh.

Mr. R. L. Smith:† I have been interested in all plans for the development and growth of Pittsburgh and Allegheny County for many years, but having been absent from the city for the last two years I have in a measure lost track of developments. The paper of the evening has therefore been very instructive to me. In my judgment the scope of investigation of the Commission could profitably be widened so as to include all of Allegheny County. What the county needs as much as anything else is a comprehensive major highway projection for the future development of the county along parallel lines with city improvement with a view to the eventual absorption of the county by the city.

This need is immediately pressing especially in the South Hills district—the next great area due for rapid expansion in the next decade, due to the approaching completion of the Liberty bridge and tunnel.

Under present methods of procedure real-estate interests may subdivide their tracts largely to suit their own individual ideas as to greatest financial returns, paying no attention either to their connection with adjacent or future allotments or to the working out of a harmonious whole. The result of this hit-or-miss method of planning is that in the next twenty or thirty years the city will be confronted with the same difficulties as obtain to-day in the installation of its major street system.

The entire county of Allegheny should be included in the survey and placed in charge of this or a similarly constituted engineering commission. This body should project upon a series of county maps such a major street or highway system for the information and guidance of future generations, so that anyone contemplating subdivision of his property would be compelled to conform thereto. These remarks are especially applicable to the projection and establishment of lines for the main thoroughfares radiating from the city, over the county—these routes being largely determined by the difficult topographical conditions peculiar to the location of the city.

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*Assistant Engineer, County Engineer's Office, Allegheny County, Pittsburgh.

†Civil Engineer, Pittsburgh.

MR. J. G. SYLVIUS:* I did not come here to talk but to listen. I was very much pleased with the paper.

One thing occurred to me—if every plan in the county is laid out by an engineer, why don't you train up the engineers not to lay them out unless they do conform in some way to the standard outline?

MR. C. M. REPPERT:† I do not think too much can be said in favor of this paper, in getting up this city plan.

The reason the city is not now following the recommendation of the Committee in more instances is, I think, because the funds appropriated have been based on a plan for widths and location differing from those provided by the Committee, and so many of these improvements now under way are so badly needed that it is impossible to abandon them immediately. If they were to go by the board now it is doubtful when thy could be put through. It is better to take what we can get than to get nothing. I think the present thought is that the present city is not going to finance the major or greater part of the scheme. This is going to be financed by the people, therefore I think the remarks that Mr. Smith made as to development of the secondary street system are of the utmost importance.

If we provide a better lay-out in our new residence districts, we will provide cheaper and better home sites, and encourage home building, and that means that new traffic extensions will lead to development of bigger and better business.

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*Member, Board of Viewers, Allegheny County, Pittsburgh.

†Chief Engineer, Bureau of Engineering, City of Pittsburgh, Pittsburgh.

I just made a few rapid figures based on 130 miles of new streets and widenings at $50 a foot on a 60-foot street. It would run to about $32,000,000, exclusive of damages, and the damages are by far the greater part of the cost.

First, the question of municipal practice comes face to face every day with the question of cost, and it may be that these costs are excessive; but I do not think we should lose heart because some improvements must necessarily be carried out not in exact conformity with this most excellent plan.

Take Brownsville Avenue, on the South Side. It is one of the few main thoroughfares leading up to the hilltops. South Eighteenth Street was improved some years ago, and is a fairly good street for reasonably fast traffic. Brownsville Avenue is now being improved. The Committee's plan calls for a much wider street and better location. I think perhaps that plan will be carried through some day, but we are now improving Brownsville Avenue so as to open it up for traffic immediately. We are spending something in the neighborhood of $200,000, and we will have another street in addition which will be passable and which will encourage traffic to the south hills. There is nothing in the way of preventing, at some future time, carrying through the much better thoroughfares which will be in an entirely different location.

I am disappointed myself in seeing so few engineers here to-night. If the engineers are not going to get behind this plan I am afraid it will not go very far; and the first step in better Pittsburgh and better street planning is to get this plan before the people and before the municipal authorities. The mere plan itself is most important, but there are a great many steps afterwards. Perhaps a change in taxation may be necessary to finance it.

I would like to find out from Mr. Wooldridge whether the Committee is going to investigate the question of taxation. One reason why Pittsburgh has become the workshop of the world is that taxation of manufactures has been very low. Perhaps we have reached a point now where we have attracted so many people here that we will not be able to proceed with our great improvement scheme unless we provide some scheme of providing the revenue. We have not been able to go ahead in the city with precise surveys, and every year the city is paying the penalty in poor engineering works because we have not been provided with funds. That is an important element in carring out a city plan. We must have first-class engineering work. Surely if the engineering projects cannot be carried out wisely and economically our plan is going to get a very serious set-back.

MR. C. L. WOOLDRIDGE: Replying to Mr. Reppert's question as to whether the Citizens Committee is going to investigate the matter of taxation, I would state frankly that we have avoided that subject at this time, as we feel at present this is a matter which we, as a Committee, should not even attempt to influence. Before we are through with our work, it may be that we will have to consider the subject. When a small group of people started to make a plan for the city of Chicago, the politicians and city authorities said they were crazy, as Chicago could not stand any heavier taxes, and yet to-day that city is spending something in excess of seventy million dollars for the improvements recommended by the Planning Commission. They have torn out whole squares and constructed one of the most magnificient boulevard systems in the world. Pittsburgh can certainly do the same thing. In my paper I was compelled to mention only a very few of the projects recommended, while, as a matter of fact, a whole evening's discussion could be devoted to almost any one of them. Our Committee proposes to create a demand for these improvements and anticipates that a method of paying for them will naturally develop.

MR. F. B. CHALFANT:* In 1914 we started a precise survey but had no special appropriation for the work which was carried on from time to time by the regular employees in the Division of Surveys. We measured a base-line having a length of about 5000 feet in Sharpsburg along the Allegheny River. The primary triangulation system was about sixty per cent. completed when we were compelled to stop, as our force was materially reduced during the war and it was necessary to keep all the men on routine work. Of course, it is something that we all know should be completed and we have tried each year to have Council authorize us to proceed with the work and make an appropriation for the necessary employees but have never met with any success.

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*Division Engineer. Division of Surveys, City of Pittsburgh, Pittsburgh.

MR. J. M. RICE:* I feel that I should second the remarks of the other gentlemen in complimenting Mr. Wooldridge upon his paper, and I regret that we have not more of the engineers of Pittsburgh here to-night.

I think we ought to start a publicity campaign for the engineers and have them familiarized with this major street plan.

Mr. Sylvius pointed out that the engineers are to blame, and I think there is a lot of truth in his remarks. However, there are a good many reasons why a practising engineer in laying out a plan in the country cannot comply with all the desirable conditions because of the limitations put upon the amount of money to be spent. It is utterly impossible to lay out a hundred acres and deal with all the factors to which the Citizens Committee has given consideration. This careful detailed study, based upon facts and experience and history of other cities which have gone through the same problems, should be of great value to all of our citizens. We have to be guided by legislative action, and by the City Planning Commission one of whose functions is to see that lot plans which are proposed within a distance of three miles of the city's present limits conform to and are suited to a general plan. I do not believe that anything so far has been done upon this for the reason that the City Planning Commission has not the funds to do it. That would mean doing what the Citizens Committee has done for the territory within the city limits, and in one or two cases outside the limits.

Of course there are a lot of demands for the taxpayers' money but as engineers I think we ought to be far more active—and especially such members of this Society as come in close contact with the municipal engineering department who should be much more active to impress upon the legislative bodies of the city, county, and boroughs the importance of this plan.

*Consulting Engineer, Pittsburgh.

You must realize that the Citizens Committee has taken care of only the city. We have outside the city a population practically equal to that residing within the municipal boundaries, and their problems are just as acute and have been just as badly solved as those of the older city. If this Citizens Committee can by publicity in the city proper—and I hope the publicity will extend also to the boroughs—awaken an interest in the subject among the people who are influential and interested in these things, I think we can hope for a more active functioning of the City Planning Commission, and probably some strengthening of the County Planning Commission, which, I understand, has devoted practically all of its energies to the question of roadways.

We should all read this particularly valuable report and do what we can in spreading the gospel of comprehensive planning, whether it is carried out to-day or twenty or thirty years from now.

Pittsburgh was fortunate in having some ten years ago a committee on city planning, which produced a report, and while that report was not as well financed and the interest was not kept up in it to the extent that it should have been and proper publicity was not given to it, still it is very interesting to find that a number of its recommendations are now being carried out. I believe the Boulevard of the Allies is one, and the widening of East Ohio Street is another. While these things may have been considered by other people before the members of the old commission actually put them on paper, still I think the mere fact that they suggested something concrete was very helpful.

I do not believe that we want to let Mr. Wooldridge's statement about Pittsburgh's population go unchallenged. I hope that he will point out in his final revision of the paper that, while the city has not gone forward rapidly, the district as a whole has kept reasonable pace with other metropolitan districts. There seems to be ample space within the city for a much larger population, but without improved transportation and housing conditions we can never hope to occupy all the available lands in the city.

I would like to ask Mr. Wooldridge whether aviation has been considered at all in this plan and what would be the effect of that system of transportation?

MR. C. L. WOOLDRIDGE: Only to a very limited extent. We have been asked to assist in finding a suitable aviation field in Pittsburgh and, so far, we have been able to make no definite recommendation. It is my opinion that, unless we can obtain reasonably good landing conditions close enough to the city so that mails can be handled without loss of time, Pittsburgh can never take a prominent place in this respect. One possible landing place seems to be worthy of investigation and that is the level area on top of the present filter beds of the Pittsburgh filtration plant at Aspinwall. These beds are covered with concrete groined arches with an earth fill on top about three feet thick. Ventilators project through this fill and these would have to be leveled off.

MR. J. M. RICE: About a year ago some of the local people were interested in aviation and asked me that question, and I told them that it was a very serious problem. Of some 80 acres at the filtration plant, about 56 are underground reservoirs in which the water passes through beds of sand which are covered by a system of concrete arches, and on top of the arches some three feet of earth. The question I put to the aviators at that time was, what load would we have to take care of, and they were unable to answer. The filters of course were designed for a certain weight, and if a plane would take a sudden plunge it might go through. I could not find out what loads would have to be considered, and I believe that that would be the first question to be solved. After that is solved it might be a very simple matter to find out whether they could be used, or whether they could be strengthened to be used.

MR. C. L. WOOLDRIDGE: We have seen private aviators establish fields at Oakmont and at a point below Carnegie, and Schenley Park has been used occasionally although the landing space in the latter is so limited that it is not popular.

MR. J. M. RICE: What is the matter with Neville Island?

MR. C. L. WOOLDRIDGE: They say the bridges are a detriment and also that the fogs, which are so frequent over Neville Island, are undesirable. So far as I know now, the filtration plant offers the only possible field reasonably close to the Pittsburgh post-office. Of course, permanent buildings could not be built on top of the filtration beds but there is ample room surrounding this area for such buildings. My idea is that the space over the beds woud be used only for a landing place. Again, I do not know what loads would be imposed on this concrete work in landing a heavy aeroplane but I should not think that this would be a very serious condition.

MR. C. M. REPPERT: Is anything going to be done in the future to control the order in which these things will be carried out?

MR. C. L. WOOLDRIDGE: I think this is a matter which will have to be governed entirely by the needs of the situation when they come to the execution of the various projects. It is true that in the Committee's playground report there is laid out a definite program to provide playgrounds for the entire city; in other words, we have established a chronological order in which the playground system should be developed, and the city council has practically agreed to follow the consecutive order that has been recommended. Council has departed from this in some degree but I believe is sincerely trying to follow the recommendations. Of course, any program of this kind will cover a long period of time and other circumstances now unknown may make it advisable to depart from it.

MR. C. M. REPPERT: It seems to me unless some such program is presented there will be danger of part of the scheme not being carried out, and as a result the funds available for the reimprovement of the city will be dissipated. I think that, unless a fairly accurate program is laid down, very little will be accomplished.

MR. C. L. WOOLDRIDGE: I shall be glad to place that point before the Citizens Committee. I think there is a lot of value in it and cannot see any reason why it should not be done. We are now trying to influence the city authorities to carry out present construction work in accordance with our recommendations and are meeting with some success. Ultimately, when the majority of our citizens understand this plan, there is no question but that there will be sufficient demand to require the city to follow it. This has been the experience in other cities such as Chicago, St. Louis, and others.

MR. P. W. PRICE: There is one feature the importance of which has not been fully brought out in this discussion. The Citizens Committee report calls for the widening of about 108 miles of streets. Something was also said about proper planning of suburban lot plans and proposed new streets or additions to the boroughs. It seems to me that some provision might be made—it might require some legislation—by which set-back lines could be universally adopted in the planning of new additions. In the first place, when a town is laid out or additions are added, you do not know how the town is going to grow. I think prvision might be made whereby a 10-foot set-back or building line should be established on each side of every street. As long as they remain strictly residence streets, the 40-foot or 60-foot width is all you need; but when they become business streets, as some of them will, at least a 60-foot or possibly an 80-foot width would be required. If a 60-foot street was originally adopted the same 10-foot set-back should be provided, so that it could be at sometime widened to an 80-foot street. Any person buying a piece of property for residence purposes would have a 10-foot line which would come into use only in case that street should be changed from a residence to a business street; and during the transition period, business blocks, apartment houses and stores would be set back to that 10-foot building line, so that it would not be a hardship to anybody when eventually the street became an 80-foot street. You are up against it in Pittsburgh now. Where it is necessary to widen streets there is no set-back line. The only way that I can see whereby this can be taken care of with fairness to all concerned would be by an ordinance providing that in cases where a board of viewers decided that a set-back line would work a hardship on the property owner, due to present improvements extending over his line, the city be required to pay a small annual rental for such strips of land thus affected until such time as the property is actually taken over and the improvement made. Some such provision would discourage the indiscriminate use of this power by the city for long periods before the improvements could be made.

There is at least one instance of which I have heard where set-back lines were provided for in the original street plans of a town or small city. I cannot now recall where that town is but it has worked out very well and when a residence street was transformed into a business street, the additional width was provided without cost to anybody. This might be called the ideal arrangement. It should be provided for in all new towns or in additions to existing municipalities. If this matter were covered in all deeds to lot owners, in a way somewhat similar to building-line restrictions as now provided for in many residence districts, there would be no trouble experienced either during the transition period from a purely residence street to a somewhat restricted business district—as, for instance, when stores or apartments are built at certain important street intersections—or after the possible ultimate transformation to unrestricted business thoroughfares. That is when the additional width becomes very important and would have the effect of automatically adding many dollars per foot front to the value of all property that would thus become business blocks on an important main thoroughfare which had, by this system, become changed from a 60-foot residence street to an 80-foot traffic artery.

Would it not be well to adapt some carefully considered plan to the existing conditions in Pittsburgh, well in advance of the actual street widening? This could readily apply without any cost to property where the proposed widening was not already occupied by buildings. In the case where present improvements were affected, some nominal payment should be made by the city in advance to reimburse the owner for any loss of revenue which might result and which would have to be determined by a board of viewers.

MR. FREDERICK BIGGER:* Commenting upon Mr. Price's suggestion, I believe the desired result would be secured in a better way by the application of zoning regulations which are designed to control the use, area, and height of buildings. Such regulations are devised to assure that the right buildings will be in the right places. In any new town it would be evident that major streets would pass through territory which would ultimately become residential and commercial or industrial in character. Reasonable demarcations between such districts could easily be made in the beginning. Land for major streets of adequate width could be set aside at the same time, even though the actual roadway would not be paved to its final width until increase of traffic should make it necessary.

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*Secretary, Citizens Committee on City Plan of Pittsburgh, Pittsburgh.

In the case of old towns the problem is more difficult. It is possible to zone such towns also and to fix the limitations of districts of different character. Such regulations may safeguard the future and reduce the cost of certain street widenings, particularly in areas now residential in character; but these regulations are not retroactive. Therefore, in cases where building development has gone so far that zoning regulations will be of no assistance in securing wider streets, and where such widening will be costly, the principle of the set-back line might be used. This is the principle which the city proposed in its contemplated widening of Grant Street. You will find this principle mentioned on pages 61 and 62 of the major street report, now under discussion. The best illustration of the use of a set-back line is Chestnut Street in Philadelphia. That street, between the Schuylkill and the Delaware, had been in process of widening since 1880. The widening ordinance fixed the new street lines; it prohibited new buildings within such lines; and it provided that, if the owner rebuilt his building or altered it to the extent of 50 per cent., the building should be set back to the new line so the city could widen the street at that point. Of course, compensation was to be made when the land was taken. A variant of this process might be used whereby an owner would be permitted to build a new building entirely or partly upon the strip ultimately to be taken by the city, but this would be at his own risk and he would receive no compensation for such new construction when the property was finally taken.

Mr. C. S. Davis:* The practice followed in some other cities of requiring all plats of new territory to be submitted to a board for approval before the same can be filed for record, might be worked out on new territory to advantage.

---

*Consulting Bridge Engineer, Pittsburgh.

A board could be created with the necessary legal authority to approve all plats in Allegheny County and this board could co-operate with other boards lacking legal authority and bring about a plan of development properly co-ordinated.

MR. W. M. AUSTIN:* Pittsburgh needs city planning more than any other large city in this country, except possibly New York. Opening a new street in Chicago, Philadelphia, Detroit, or Buffalo, means only acquiring the right of way and building the street at practically the existing grade. They are not hampered by the topographical disadvantages that we have here, and do not have to move millions of yards of earth before starting construction.

I have listened with interest to the paper and the discussion, and think that ultimately Pittsburgh will be greatly benefited by what has been and is now being done.

MR. WINTERS HAYDOCK:† I believe Mr. Wooldridge has presented the case very clearly. It was not his intention, as he said, to go into the details of the major street plan. These details can be learned by a perusal of the report, which will be made available to any member of this Society. I believe it will be to the advantage of every member, if he has not already received a copy of the report, to apply to the Citizens Committee on City Plan, and to give the report as careful attention as his time will permit. I think he will find some very interesting matters in it and will be able to study more in detail the features of this paper, which could be presented only in a general way tonight.

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*Electrical Engineer, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

†Chief Engineer, Citizens Committee on City Plan of Pittsburgh.

PROCEEDINGS OF THE

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*Memior on following pages.

JOHN ABIEL ATWOOD

Chatham, Mass., Feb. 8, 1857.
Beaver, Pa., Feb. 29, 1920.
Joined Society, April 1891.

John Abiel Atwood, Chief Engineer of The Pittsburgh and Lake Erie Railroad Company, with offices at Pittsburgh, Pa., died at his late residence in Beaver, Pa., at 9:30 P. M., February 29, 1920, after a ten days' sickness of influenza, which later developed into pneumonia with pleurisy complications.

Mr. Atwood was born at Chatham, Mass., February 8, 1857, and was graduated from the New York University in 1878, with the degrees of B. S. and C. E. From the date of his graduation to March, 1879, he was transitman of the New York Elevated Railroad. From 1879 to 1880 rodman and leveler of the Elizabeth City and Norfolk Railroad (now the Norfolk Southern Railroad). From 1880 to 1883 draftsman of the New York, West Shore & Buffalo Railroad. From 1883 to 1885 Assistant to Chief Engineer of the Tenth Avenue Cable Railway in New York City. From 1885 to 1887 Resident Engineer of the Chautaqua Lake Railroad. From 1887 to 1889 Assistant Engineer of the Lake Shore & Michigan Railway (now the New York Central Railroad). From 1889 to 1896 Engineer of Construction of the Pittsburgh & Lake Erie Railroad. From 1896 to the date of his death, Chief Engineer of the same road.

The Pittsburgh & Lake Erie Railroad, during his tenure of office as Engineer of Construction and Chief Engineer, has grown from a single track to a four-track railroad. This development necessitated practically the reconstruction of the entire system. One of the first engineering feats performed by Mr. Atwood was the relocation on a major scale of the main line, resulting in a large reduction in the grades and a marked improvement in the alignment.

Under his supervision large terminal, storage and classification yards, with round houses, locomotive and car repair shops, etc., have been designed and constructed at various points. All bridges have been rebuilt; one of the largest being a pin connected cantilever structure spanning the Ohio River at Beaver, Pa. This bridge by reason of having many novel details embodied in its design attracted widespread attention at the date of its construction. The trusses are protected against damage by derailed equipment by skid girders, which were designed and patented by Mr. Atwood.

During his incumbency the main line has been extended and several branch and tributary lines have been constructed. The principal one of the latter being the Lake Erie & Eastern Railroad which is located through the heart of the City of Youngstown, Ohio. The location and construction of this road was replete with engineering problems.

Attractive passenger station buildings and station ground layouts, designed in the Chief Engineer's office, have been built along the entire length of the road.

In the City of Pittsburgh a complete terminal layout has been constructed, the principal items of which are a modern Terminal Passenger Station and General Office Building, a Terminal Freight Building and a large fireproof Storage Warehouse.

The true engineer is a man of vision and achievement. He derives pleasure from study and design, especially when the problem that confronts him is of an unusual type and demands original treatment. He should temper the ideal with the practical, guarding against waste and extravagance on one hand and narrowness and imperfection on the other. The possession and proper use of these qualities largely define his right to be styled an engineer. The work performed by Mr. Atwood on the Pittsburgh & Lake Erie Railroad during the quarter of a century that he served as its Chief Engineer will bear for many years to come mute testimony to the fact that he possessed in a large degree the qualities above described.

He was, in the strictest sense of the term, a Christian gentleman. A man of a quiet and retiring disposition possessing, however, in a marked degree, the ability and the willingness to give due consideration to every phase of a controversy brought before him for adjudication. He commanded the highest respect of his superiors and subordinates alike, to all of whom he was at all times courteous.

One said of him a few days after his demise as in public he recounted somewhat in detail the virtues that made up the character of this really great man that "The crowning work of his life was the development of his own high character and the highest tribute that can be paid him is the simple statement that he was 'John Atwood.'"

Mr. Atwood was an elder in the First Presbyterian Church in Beaver; a member of the Duquesne Club of Pittsburgh; a member of the American Society of Civil Engineers; a member of the Engineers' Society of Western Pennsylvania; Second Vice-President and Director of the American Railway Engineering Association (in which organization as chairman of the Committee on Rail he performed a most valued service); and a Director and Vice-President of the Beaver Valley Country Club.

He is survived by his widow, one son, William B. Atwood of Youngstown, Ohio, and two daughters, Mrs. Julia Atwood Peters and Miss Edna Atwood at home.

WILLIAM ANDREW BOLE

Pittsburgh, July 12, 1859.
Pittsburgh, June 16, 1919.
President, 1900.
Joined Society, May 1884.

Mr. Bole was born in Pittsburgh, Pa., July 12, 1859, of Scotch-Irish extraction, and lived, worked and died there. He received his education in the Public Schools and the University of Pittsburgh.

His father, Hugh M. Bole, was a prominent manufacturer of tools and machinery, having his shops at Duquesne Point.

Mr. Bole, all his life, was connected with the foundry business and the making of machinery. As a boy, when not in school, he was helping in the shop. He was a great traveler and had a world wide experience as a mechanical engineer and was considered an authority as such. In 1882 he became connected with the Westinghouse Industries, especially the Machine Company, where he remained, serving them loyally for thirty-seven years, until his death.

He became a member of the American Society of Mechanical Engineers in 1884 and continued as such until his death. He was a past president of the Engineers' Society of Western Pennsylvania, also of the American Foundrymen's Association. He was also a member of the Duquesne Club and of the Shady Side Presbyterian Church of Pittsburgh.

In 1883 Mr. Bole married Miss Emily J. McCracken of Pittsburgh. His widow, one daughter Mrs. W. C. Douglas, three grand children and two brothers F. H. and G. M. Bole survive.

JOHN ALFRED BRASHEAR

Brownsville, Pa., November 24, 1840.
Pittsburgh, April 8, 1920.
Member, March 1884.
Honorary Member, February 1903.
President of the Society, 1889.
Vice-President, 1887–1888.

The long and wonderfully successful career of "Uncle" John Brashear, demonstrates the encouraging fact that our lives are largely what we make them, even under the most trying conditions. For he managed to get and impart "Sweetness and Light" throughout his twenty-one years as a Pittsburgh boss millwright, whose "day" was often multiple—limited only by the needs of the mill, and the job in hand.

Dr. Brashear joined the Engineers' Society of Western Pennsylvania about the time he moved from the South Side to which was then Allegheny, and founded the astronomical and physical instrument works which were the natural result of his unswerving loyalty to perfect workmanship; and his devotion to the increase of knowledge and the happiness of his fellow-men.

The Society doubtless attracted him greatly in the days when Pittsburgh was not so well endowed with science as it now is. He became at once an active and inspiring member, and so remained until the close of his valuable life, one year ago, when his ashes were joined with those of his devoted wife, Phoebe Stewart Brashear, under the dome of the Allegheny Observatory, which forms a worthy monument to the character, genius and public services of both.

He received many degrees and honors at home and abroad; but he liked best the cordial "Uncle" John from old friends, whether of the mill, school or the more prominent walks of life.

Our Society affords many examples of the value of ability, fidelity, study, early poverty and hard work as the foundation for a useful life of service.

To all such, present and future, may the memory of "Uncle" John Brashear be and remain an abiding source of hope and inspiration.

DR. FRANCIS C. PHILLIPS

Philadelphia, Pa., April 2, 1850.
Ben Avon, Pa., Feb. 16, 1920.
Joined Society, Jan. 1880.

Dr. Francis Clifford Phillips died at his residence, 144 Ridge Avenue, Ben Avon, Pa., on Monday, February 16, of influenza-pneumonia, passing away in the same peaceful manner which characterized his life.

He was born in Philadelphia, April 2, 1850, the son of William S. and Fredericka Ingersoll Phillips. He received his early education at home from an unusually capable and devoted mother. In 1864 Dr. Phillips studied at the Academy of the Protestant Episcopal Church in Philadelphia, and in 1866 entered the University of Pennsylvania, where he obtained his A. B. From 1871–1873 he studied under Regimus Fresenius at Wiesbaden, Germany. During the latter year he was private assistant to Prof. Fresenius. He then spent a year at the Polytechnic School at Aachen (Aix-la-Chapelle). Here he was associated with Prof. Landolt. Professor Phillips was unable to complete his studies abroad because of the poor health of his father. He returned to America and during the following year became instructor in chemistry at Delaware College. In 1875 he was appointed to the teaching staff of the University of Pittsburgh, then the Western University of Pennsylvania, where he taught for forty years, retiring as Head of the Department in 1915. For many years he taught chemistry, geology and mineralogy. Even in the writers student days (1898–1902) Professor Phillips still taught all branches of chemistry and mineralogy. In 1878–1879 he also lectured to the students in the Pittsburgh College of Pharmacy, where he succeeded the late Prof. John W. Langley, a brother of the late Samuel P. Langley, then at the Allegheny Observatory and afterwards secretary of the Smithsonian Institution. In 1879 he received the degree of A. M. from the University of Pennsylvania, and in 1893 the Ph. D.

He was married in 1881 to Sarah Ormsby Phillips, daughter of Ormsby Phillips, a former mayor of Allegheny.

In 1915 Dr. Phillips retired from active service in the University of Pittsburgh under the pension system of the Carnegie Foundation. On this occasion his colleagues and the Alumni tendered him a banquet at which he was presented with a check for one thousand dollars for a little vacation with "Mother" Phillips. Professor Phillips was so solicitous of the safety of his dear wife, that though they intended visiting the Bermudas and the Panama Canal Zone, the war, with the possible accompanying danger in ocean travel, caused him to postpone the trip which was never realized. At the banquet, the fruit of his labors as a teacher was in plentiful evidence, including such men of prominence as George H. Clapp, J. M. Camp, Walther Riddle, C. M. Johnson, Charles Kellar, Charles Dinkey, W. A. Hamor, Jacob Rosenbloom, the late Robert Carnahan and many others. It was an evening of tribute to one who had so conscientiously given to former students all that he possessed as a teacher.

Since 1915 he had been engaged continuously in research and writing in a laboratory provided by the Mellon Institute. During the recent war he conducted researches on gases in co-operation with the Gas Warfare Service.

In June, 1919, Dr. Phillips received the honorary degree of Doctor of Science from the University of Pittsburgh.

Dr. Phillips was an authority on natural gas in which field he held international recognition. In 1904 he published the "Methods of Analysis of Ores, Pig Iron and Steel Used by the Chemists in the Pittsburgh Region," and in 1913 a textbook of "Chemical German," of which a second edition appeared in 1916. At the time of his death Dr. Phillips had two other books well under way, one on the "Life and Work of Joseph Priestley," the other on "Qualitative Gas Reactions."

EMIL SWENSSON

Aalborg, Denmark, Dec. 12, 1858.
Pittsburgh, Pa., May 13, 1919.
President, 1897.
Joined Society, April 1887.

Emil Swensson was born in Aalborg, Denmark, on the 12th day of December, 1858, the son of Jean and Marie Katherine Swensson. He was one of a family of seventeen children.

He spent his early boyhood days in Halmsted, Sweden. He was graduated from Chalmers Polytechnic Institute in June, 1878, as a Civil and Mechanical Engineer. He then repaired to Germany and continued his studies and after nearly two years' time so devoted, he was engaged by the town of Warberg, Sweden, as Engineer in Charge of Harbor Improvements. Overhearing his father one day expressing his doubts as to his ability to make good, he resolved to come to America, where he believed that his independent spirit would succeeed in demonstrating that his father had greatly underrated his ability and perseverance. His father subsequently admitted his mistaken judgment, and naturally became very proud of his talented son.

However, his early days in America were anything but cheerful ones. He found himself greatly handicapped by his lack of knowledge of the English language, and for some time he could secure no connection with work within his profession. Nothing daunted he went to work at hard manual labor in the first projected tunnel under the Hudson River. Meanwhile he applied himself to the study of the language of the land. His first professional engagement was with Edward Raht, an architect in New York City, as a draughtsman. He remained there until January 1, 1882, when he embraced the opportunity of becoming one of the Assistant Engineers in charge of a locating party, on the South Pennsylvania Railroad, which road was designed to extend from Harrisburg to Pittsburgh. Eventually he was in charge of construction. On October 31, 1885, the construction of this railroad being abandoned, he went into the employ of the Phoenix Bridge Company, and in February, 1885, he located in Pittsburgh, where he spent the balance of his life, going into the employ of the Keystone Bridge Company. That company eventually became a part of the American Bridge Company. He remained with the enterprise sixteen years, rising from the position of draughtsman to that of Chief Engineer, then General Superintendent, and finally Manager of Works.

From January 1, 1901, he engaged in private practice with offices in the Frick Building He yielded to the claim of ill health and closed his active life in 1917 He was connected with many important works of a wide range as consulting engineer, such as the subways and elevated roads in New York and Boston, sewage system in New Orleans, and the Pennsylvania State Highway bridges. He was particularly active in local projects, having acted for the United States Government in the plans for raising the bridges over the Allegheny River, located the first South Hills tunnel, planned a complete system of elevated railways for this community, and for a time acted as Consulting Engineer for the Pittsburgh Railways Company in the matter of operation.

Within the profession, Mr. Swensson was known as a close student, an advanced thinker, a strict disciplinarian, a man of fine judgment. His bearing was dignified, but he was ever ready to join in the wholesome amusements of life. He was of an engaging personality and obliging disposition, who, starting in his life work alone and friendless, attached to himself a wide circle of friends. Measured by the results, his was a successful life.

He became a member of this Society in April, 1887, was elected a director in January, 1893, was vice-president during the years 1895 and 1896, and president during 1897. In the earlier days of the Society, when it required the best thought of its membership that it might become a firmly established institution, he worked indefatigably for its success. It will be noted that his membership in the Society covered more than half his life.

He married Catherine Jordan of Mt. Pleasant, Pa., on Christmas Day, 1883, and was the father of four children: Otto, Christine, Stuart and Henri.

He passed away on the evening of May 13, 1919, at his residence, 5511 Hay Street.

BOARD OF DIRECTION

The Regular Monthly Meeting of the Board of Direction of the Engineers' Society of Western Pennsylvania was held in the Society Rooms, Union Arcade Building, Thursday, January 6th, at 4:15 P. M., President W. C. Hawley presiding, Messrs. Neilson, Danforth, James, Fohl, Hunter, Stucki, Hildner and the Secretary being present.

The Minutes of the last regular meeting held December 2, were read and approved.

The applications of the following gentlemen, having been regularly published to the Society pursuant to the action of the Board, were elected to membership:

MEMBERS

Becker, Joseph
Boothman, Dale M.
Erhard, J. M.
Heppenstall, C. W.
Lamm, Lee L.
Lanahan, Frank J.
Lehman, Albert C.
Lowe, Wilfrid D.
Munro, Willam L.
Patterson, W. J.
Schiller, William B.
Sutherland, William Chester
Weir, E. T.

Applications were received from the following gentlemen and their names ordered published to the Society. Assignment to the various grades of membership is as follows:

MEMBERS

Brandt, C. A.
Durkee, J. O.
Jones, B. F.
Miller, John F.

JUNIORS

Marshall, W. A.
Hayes, Charles Ellis
Cook, E. C.

The following applications were received for transfer to higher grade of membership and after discussion the Secretary was requested to write these gentlemen, advising that they had been transferred to the grade of Member:

McKnight, Charles, Jr.
Weber, K. B.

The Secretary reported the death of the following gentlemen:

Wolfel, Paul L..................	Joined June, 1905	Died Dec. 28, 1920
Patton, A. W......................	Joined April, 1900	Died Dec. 14, 1920

Letters of resignation were received from the following gentlemen, which after discussion were ordered accepted:

Blick, James, Jr.
Brennan, James I.
Brewer, W. A.
Carroll, J. G.
Coffin, W. C.
Cushing, W. C.
Day, C. T.
Dougherty, J. W.
Douthett, G. M.
Hardie, Alex.
Hardie, J. B.
Kelly, R. M.
Kerr, William
Kilgour, David
Maccoun, A. E.
Murdoch, Harry
Maurer, R. E.
McKenna, A. G.
Ostrom, J. N.
Spilsbury, H. G.
Stupakoff, S. H.
Tonnele, Theodore
Vauclain, A. C.
Williams, C. H.

Mr. James, Chairman of the Entertainment Committee, reported that the Annual Banquet arrangements had been completed, with the following speakers: Mr. Daniel C. Roper, Mr. James A. Emery, Mr. Ellis Parker Butler and Mr. Arthur W. Thompson as toastmaster.

Mr. Speller, Chairman of the Finance Committee, reported that the Finance Report had been audited for November. Receipts for November, 1920, exceeded that for the same month last year by $751.42, and there remains a small credit balance in the General Fund.

In the absence of Mr. Schatz, Chairman of the House Committee, the Secretary reported an evening attendance of 62 for the month of December.

Mr. W. B. Spellmire, Chairman of the Publication Committee, sent in a written report, as he was unable to attend the meeting, stating that a letter from Mr. Samuel E. Duff, our past president, was presented to the Committee, offering valuable suggestions in regard to changes which will involve the form of our PROCEEDINGS, announcements of meetings and all other published matter.

Mr. Spellmire suggested that the Board direct the Secretary to estimate the total costs of the change, which should include such matters as cost of paper, printing PROCEEDINGS and cost of printing and postage for all notices of meetings, after which time a meeting of the Publication Committee will be called and recommendations made either in favor of or against the suggested changes. As there will probably be no increase and even a possible decrease, some expression from the Board on this plan would be appreciated.

After discussion, it was moved and carried that the Secretary be requested to secure prices on the proposed changes and further, that copy of Mr. Duff's letter be sent to each member of the Board with the request that they submit their views on the matter to Mr. Spellmire, Chairman of the Publication Committee, in writing.

The Secretary stated further that Mr. Spellmire had requested that he point out if Mr. Duff's ideas were carried out, there would be no issue of announcements or any other miscellaneous notices, thereby saving approximately $50.00 to $75.00 per month in printing and postage. Under Mr. Duff's plan, this would all be included in the one publication. Mr. Spellmire would like an expression from the members of the Board as to what they think of the plan before the matter is brought before the Committee.

Mr. Neilson brought up the matter of the election of a director to fill the vacancy caused by the resignation of Mr. J. H. Minton, and suggested that Mr. John A. Hunter, whose term expires with this meeting of the Board, be nominated to fill the vacancy.

After discussion, it was moved and carried unanimously that Mr. Hunter be elected as director to complete Mr. Minton's term.

The Secretary presented the following application for the formation of a Practicing Engineers' Section of the Society, and after discussion, it was moved and carried that the application be approved and action taken in accordance with the By-Laws.

Dec. 29, 1920.

To the Board of Direction,
Engineers' Society of Western Pennsylvania:

Dear Sirs:

The undersigned members of the Engineers' Society of Western Pennsylvania, believing that the objects of this Society can be materially furthered by forming a Practicing Engineers' Section of the Society, do hereby make formal application for the formation of such a Section as provided in the By-Laws of the Society.

A number of practicing engineers in this district recently formed an organization known as the Association of Practicing Engineers, and it was found that of a membership of 40 or 50, only ten or twelve were members of the Engineers' Society of Western Pennsylvania.

This organization voted, at its last meeting, to apply for admission to our Society in a body in accordance with a special invitation issued by the Board of Direction at its last meeting and it is felt that this Section should be formed at once, in order that our Society may be in a position to carry on the work started by the Association of Practicing Engineers.

We sincerely trust that the formation of this Section will meet with your approval and that you will so report at the next regular meeting of the Society.

Yours very truly,

F. G. Ross
B. L. Skinner
W. A. Weldin
J. M. Rice
Morris Knowles
M. R. Scharff
C. M. Reppert
W. M. Judd
A. E. Duckham
N. F. Hopkins
G. H. Danforth
L. P. Blum

There being no further business, the meeting adjourned at 5:20 P. M.

K. F. Treschow, *Secretary.*

ANNUAL MEETING OF CIVIL SECTION

The Annual Meeting of the Civil Section of the Engineers' Society of Western Pennsylvania was held in the Palm Room, William Penn Hotel, Tuesday, January 4, at 8:20 P. M., Chairman L. F. W. Hildner presiding, 108 members and visitors being present.

The Minutes of the last Annual Meeting held January 6, 1920, were read and approved.

Mr. F. G. Ross, Chairman of the Nominating Committee, reported nominations of the following officers for the ensuing year:

L. P. Blum	Chairman
H. C. Cronemeyer	Vice Chairman
C. L. Wooldridge	Directors
C. B. Pyle	
B. A. Ludgate	
C. F. Buente	
A. S. Davison	

No further nominations being made it was moved and carried that the Secretary be instructed to cast a unanimous ballot for the members named, who were thereupon declared elected.

There being no further business, the meeting adjourned and the Regular Bi-Monthly Meeting was called to order by Mr. Hildner, in the absence of the new chairman, L. P. Blum.

The Minutes of the last Bi-Monthly Meeting held November 2, were read and approved.

There being no further business, the paper of the evening on "Erection Methods for Heavy Viaduct and Bridge Construction, Showing the Erection of Belly River and Deep Creek Viaducts and the Quebec Bridge," was presented by Mr. George F. Porter, Chief Engineer, The Canadian Bridge Co., Ltd., Walkerville, Ontario (formerly Engineer of Construction, St. Lawrence Bridge Co.).

The ensuing discussion was participated in by: Edward Godfrey, Struct. Engr., Robert W. Hunt Co.; C. B. Pyle, Engineering Dept., McClintic Marshall Co.; E. V. Braden, Engr., Pittsburgh, Chartiers & Youghiogheny Railway; George L. Christy, Chf. Engr., Pittsburgh Des Moines Steel Co.; L. F. W. Hildner, V. P. & Chf. Engr., Pittsburgh Bridge & Iron Co., and the author.

It was moved, seconded and carried unanimously that a vote of thanks be extended to Mr. Porter for the very interesting and instructive paper presented.

On motion the meeting adjourned at 11:00 P. M.

K. F. Treschow, *Secretary.*

ANNUAL MEETING

The Forty-first Annual Meeting of the Engineers' Society of Western Pennsylvania was held in the Palm Room, William Penn Hotel, Tuesday, January 18, at 8:20 P. M., President W. C. Hawley presiding, 58 members and visitors being present.

The Minutes of the last Annual Meeting held January 20, 1920, were read and approved.

The annual report of the Board of Direction, which included the reports of the Standing and Special Committees, the Sections and the Treasurer, was read as follows:

REPORT OF BOARD OF DIRECTION

The Board of Direction of the Society held ten regular and three special meetings during the year, at which routine business of the Society was transacted.

During the year there were nine regular, one special and the annual meeting of the Society. The total attendance was 900, the average being 90. The maximum attendance was 148 at the February meeting and the minimum 26 at the March meeting. The average number participating in the discussion of papers was six.

At the close of the year, the membership of the Society was as follows:

Honorary Members	1
Members	1030
Associate Members	53
Associates	26
Juniors	69
Student Juniors	2
Total	1181
Dropped	24
Resignations	44
Removed by death	13
Total	81
Accessions	62

Respectfully submitted,

K. F. Treschow, *Secretary.*

REPORT OF HOUSE COMMITTEE

To the Board of Direction,
Engineers' Society of Western Pennsylvania:

Dear Sirs:

The evening attendance in the Society Rooms for the past year was 336.

Finance and Industry, Public Works, and Successful Methods have been added to our Library on our list of exchanges, and all subscriptions expiring have been renewed.

The furniture in the Society Rooms has been cleaned and repaired and two rugs purchased for the Library and Club Room. The magazine racks have been installed and six rubber mats were purchased for the Club Room. The Store Room has been cleaned and the back files of PROCEEDINGS rewrapped.

The question of meeting room has been discussed and it has been decided to use the Palm Room, William Penn Hotel, until another room called the Lounge is completed, as this room has no columns and is better suited for our purpose.

Respectfully submitted,
F. C. SCHATZ, *Chairman.*

REPORT OF PUBLICATION COMMITTEE

To the Board of Direction,
Engineers' Society of Western Pennsylvania:

Dear Sirs:

During the year, two meetings of the Committee were held, with an average attendance of five.

Papers presented at the general meetings	10
Papers read at meetings of various sections	13

One special meeting was held—for the discussion of the Federated American Engineering Societies—as to whether the Engineers' Society of Western Pennsylvania should join, also the manner in which the financial responsibility should be handled.

Of the twenty-three papers mentioned above, twenty-two have been published in the PROCEEDINGS of the Society, or will appear in later issues.

Mr. Samuel E. Duff, sent in a letter suggesting that we change the size of the PROCEEDINGS. The matter was presented to the Board of Direction, who requested that the letter be sent to each member of the Board, asking them to write the Chairman of the Publication Committee, giving their views, so that he could make a report to the Board of Direction at their next meeting.

Respectfully submitted,
WALTER B. SPELLMIRE, *Chairman.*

REPORT OF MEMBERSHIP COMMITTEE

To the Board of Direction,
Engineers' Society of Western Pennsylvania:

Dear Sirs:

The Membership Committee beg to report the work for the year 1920 as follows:

It was suggested that a recommendation be made to the Board of Direction for the formation of a Student Section to which students attending the Carnegie Institute of Technology, University of Pittsburgh and the Apprenticeship Courses, of the Westinghouse Electric & Manufacturing Company might join.

Invitations were sent to executives of the various companies in the Pittsburgh District and surrounding towns to join the Society and of the thirty-five invitations sent out, ten accepted.

Letters are to be written to the local members of the National Societies and all lists have been made up containing names of such members, together with titles, companies and addresses.

At the close of the year, membership of the Society was as follows:

Honorary Members	1
Members	1030
Associate Members	53
Associates	26
Juniors	69
Student Juniors	2
Total	1181
Dropped	24
Resignations	44
Removed by death	13
Total	81
Accessions	62

Respectfully submitted,
JOHN A. HUNTER, *Chairman.*

REPORT OF FINANCE COMMITTEE

To the Board of Direction,
Engineers' Society of Western Pennsylvania:

Dear Sirs:

The Finance Committee beg to report that the work done during the year 1920 is as follows:

Letters were written to delinquent members, those three and four years in arrears, advising them that if their dues were not paid within a certain time, they would be dropped from the Society Rolls. There were some dues paid up, and the balance were dropped. Similar letters were also written to delinquent applicants who had not matriculated.

The books of the Society were audited by Ernst & Ernst as in former years at approximately the same rate as last year.

Mr. Minton resigned from the Board of Direction and as Chairman of the Finance Committee, on account of leaving the city to take up a position in Cleveland, and Mr. Speller was appointed in his place for the balance of the year.

The Committee took up the matter of increased expenditures and found that 80 per cent. of the increase was due to increased cost of printing, which showed an increase of 100 per cent. There was no increase in the rate of advertising, but there was an increase of about 40 per cent. in the volume of advertising.

In November the Finance Committee was authorized to transfer $1300.00 from the Reserve Fund to the General Fund, to meet extra expenses incurred at this time.

It will also be noted from the report of the Treasurer that there is a decrease of about $650.00 in the Cash Assets for the year. We were also obliged to hold over bills amounting to about $1500.00. This deficit, as stated before, has been caused primarily by increased cost of printing.

The anticipation of this deficit brought up the question as to whether or not our dues should be increased, but it was and still is the belief of the Committee and the Board of Direction that by close economy and cooperation on the part of the members in paying their dues promptly and in helping to increase the membership that an increase in dues is not necessary or desirable at this time.

Respectfully submitted,

F. N. Speller, *Chairman.*

REPORT OF ENTERTAINMENT COMMITTEE

To the Board of Direction,
Engineers' Society of Western Pennsylvania:

Dear Sirs:

The following entertainments, inspection trips and dinner-dances were held during the year:

January 26, 1919—Annual Banquet, William Penn Hotel.
Paid attendance 855.

April 24—Inspection Trip LaBelle Iron Works. Attendance 64.
Entertainment—Carnegie Institute of Technology.
Shakespeare's "The Tempest."

May 7—Dinner-Dance—Hotel Chatham. Attendance 64.

May 15—Informal Dinner—French Naval Officers.
Hotel Schenley. Attendance 35.

June 10—Boat Excursion. Attendance 144.

September 14—Boat Excursion. Basket Picnic. Attendance 142.

October 15—Dinner-Dance—Hotel Chatham. Attendance 36.

October 22—Inspection Trip—Seamless Tube Works.
National Tube Co., Ellwood City, Pa. Attendance 80 members.

November 6—Inspection Trip—By-Product Coke Plant.
Carnegie Steel Co., Clairton, Pa. Attendance 90.

An inspection trip was scheduled to the Macbeth-Evans Glass Company, but due to alterations at the plant, it was cancelled.

One of the functions of our Society is to promote social intercourse among engineers. This can best be done by various forms of entertainments and inspection trips. At the meetings of the Society the proceedings are necessarily formal, and not much opportunity is given for the members to meet each other.

The Committee feels that during the year the stress of business has, in many cases, prevented members from taking advantage of the opportunities offered by the Society to become acquainted with other engineers in this district. It is the hope of the committee that during the coming year, more attention will be paid to this feature of our social activities Among the greatest privileges of an engineer is that of meeting other engineers and forming friendships based upon our common engineering interests. In our business connections, we as engineers, are often limited in our intercourse to a few engineers on account of the nature of the work in which we are engaged, but every engineer in this district can become a member of our Society and have a potential acquaintance of over 1200 other engineers. By taking advantage of the opportunities afforded by our Society, an engineers' acquaintance and friendship may be rapidly extended to the mutual advantage of himself and his associates.

Respectfully submitted,
H. D. JAMES, *Chairman.*

REPORT OF TREASURER

To the Board of Direction,
Engineers' Society of Western Pennsylvania:

Dear Sirs:

Your Treasurer begs to submit the following financial report of the Society for the year ending Dec. 31, 1920:

Dues 1921	$ 130.00
1920	10,815.36
1919	643.46
1918	233.25
1917	160.00
1916	87.50
1915	65.00
1914	25.00
Total dues	$12,159.57

Entrance fees	$ 645.00
Advertising	2,128.30
Proceedings	1,293.57
Society pins	60.50
Interest	967.15
Banquet receipts	5,032.00
Receipts from two inspection trips	364.50
Receipts from two dinner-dances	168.00
Receipts from two boat excursions	381.50
Receipts from sales of cuts	205.47
Receipts from sale of old chairs (25)	25.00
Receipts from dinner at Hotel Schenley	75.00
Receipts from binding Proceedings for members	3.65
Receipts from exchange on foreign check	.75
Total receipts	$23,560.06
Transferred from reserve fund November 30, 1920	1,300.00
Total	$24,860.06

Expenditures

Administration	$ 5,040.00
House Committee	4,314.54
General Society	2,488.32
Civil Section	204.31
Mechanical Section	222.19
Metallurgical & Mining Section	141.40
Proceedings	5,518.83
Library	103.65
Entertainment Committee	6,292.43
	$24,325.67

Investments

One	$1000 Butler Water Co. 5% Bond No. 9. Matures Sept. 2, 1931	$ 1,025.00
Two	$1000 Connellsville Water Co. 5% Bonds Nos. 317 and 318. Maturing Oct. 1, 1930	2,020.00
Two	$1000 Portsmouth Berkley & Suffolk Water Co. 5% Bonds Nos. 465–466. Maturing Nov. 1, 1944	2,000.00
Two	$1000 Jamison Coal & Coke Co. 5% Bonds Nos. 1502 and 1503. Maturing Nov. 1, 1931	2,000.00
Two	$1000 Union Steel Co. 5% Bonds Nos. 38642–38643. Maturing Dec. 1, 1952	2,090.00
Two	$1000 Pennsylvania Railroad Co. 4½% Bonds Nos. 27320–27321. Maturing August 1, 1960	2,070.00
Three	$1000 Jones & Laughlin Steel Co. 5% Bonds Nos. 3020–3021–3022. Maturing May 1, 1931	2,997.92
One	$1000 U. S. Liberty Bond 4¼% No. 54437. Maturing September 15, 1928	1,000.00
		$15,202.92

Assets

Permanent Fund	Dec. 31, 1919	Dec. 31, 1920
Bonds	$15,202.92	$15,202.92
Cash (Fidelity T. & T. Co.)	874.71	1,514.71
Reserve Fund		
Cash (Fidelity T. & T. Co.)	2,500.00	1,200.00
General Fund		
Cash (Diamond Nat. Bank	206.87	201.26
	$18,784.50	$18,118.89
Decrease in assets	665.61	
	$18,118.89	$18,118.89

Considering the adverse conditions prevailing during the last year as to price of material and labor, the decrease of $665.61 is easily explained. This resulted in a very high cost for printing the PROCEEDINGS. I understand from Mr. Treschow that steps are now being taken to reduce this item.

By looking at our headquarters you will fully understand the reason for the extra expenses by the House Committee. No wonder they are patronized more and more each month, especially in the evenings.

Respectfully submitted,

A. STUCKI, *Treasurer.*

REPORT OF CIVIC AFFAIRS COMMITTEE

To the Board of Direction,
Engineers' Society of Western Pennsylvania:

Dear Sirs:

Four matters of importance have been taken up by the Civic Affairs Committee during the past year, action being taken as indicated below.

1. Communication from the World Trade Club, asking the Engineers' Society to endorse the adoption of the Metric System of Standardization of Weights and Measures. This matter was taken up by the Committee and recommendation made that the Society oppose the adoption of the Metric System. Action was approved by the Board of Direction.

2. Removal of Road Commissioner R. S. Warren and the appointment of Roy Schooley. Several meetings of the Committee were held and a special meeting of the Board of Direction, at which formal resolutions were adopted protesting against the removal of Mr. Warren and the Committee appeared before the County Commissioners and presented the resolution.

3. Restrictions on Westinghouse Park. A letter was sent to the Engineers' Society from a special committee of City Councils, in which they asked that the Society remove restrictions placed in the deed, giving the property of the late George Westinghouse to the City of Pittsburgh to be used as a Park. These restrictions prohibit the use of these grounds for playgrounds. The Committee realizing that it had an obligation to the people who had so generously given their financial aid to secure this property, do not believe that it would be advisable for the Society to authorize the removal of these restrictions without the permission of the donors, and a letter was written to the two men who had been instrumental in collecting these funds, who replied that they were very much against the removal of these restrictions and as this was one of the conditions under which the donors contributed, they wished to protest against any such action on the part of the Society.

Copies of these letters were then sent to the Committee from Council stating that the Society did not feel, in view of the responses received that they were in a position to comply with their request.

4. National City Planning Commission Conference. Mr. G. M. Baker, for the Committee, attended a meeting of the City Planning Commission December 23, at which Mr. A. J. Kelly, presided in the absence of the chairman. The meeting was attended by the various Civic and Affairs Committees of Allegheny County and plans for inviting the National Organization to hold their conference here in April or May, 1921, were taken up. A ways and means committee was appointed by the Chairman to get the proposition under way.

Practically all the representatives present did not have authority to speak for their various societies and it was moved and seconded that the representatives get this authority and attend the next meeting which would be held the first Thursday in January. It was mentioned, however, that no financial encumbrances would be put on the various societies in order to make up necessary funds for making the National Convention a success.

Respectfully submitted,
W. E. FOHL, *Chairman.*

REPORT OF COMMITTEE ON SOCIETY AFFILIATION

To the Board of Direction,
Engineers' Society of Western Pennsylvania:

Dear Sirs:

The Committee has now finished its work of drawing up the Regulations for the Associated Engineering Societies of Pittsburgh. These Regulations were drawn up some months ago and submitted to the various organizations in Pittsburgh, and after receiving their ideas and criticisms, the Regulations were revised and now stand completed as far as this Committee is concerned.

The American Society of Civil Engineers and the American Society of Mechanical Engineers have adopted these and wish to join the proposed Association, and we would suggest that the present committee be discontinued and that the Society take steps to make the Association a working organization.

The American Institute of Electrical Engineers and the American Institute of Mining Engineers have not yet formally taken action in regard to becoming members.

Respectfully submitted,
S. B. ELY, *Chairman.*

REPORT OF CIVIL SECTION

To the Board of Direction,
Engineers' Society of Western Pennsylvania:

Dear Sirs:

I beg to submit the report of the work done by the Civil Section during the year 1920.

Four regular meetings of the Section were held during the year. The average attendance at these meetings was 71, the maximum being 76 at the March and May meetings, and the minimum 56 at the November meeting.

An average of eleven participated in the discussion of the several papers presented. The papers presented during the year were:

January Meeting—"Construction Work by the Cement Gun Method." By A. J. White, Dist. Manager, Cement Gun Construction Co., Chicago, Ill.

March Meeting—"Surface Combustion." By A. E. Blake, Sales Engineer, Surface Combustion Co., Pittsburgh.

May Meeting—"Modern Concrete Road Construction — Machinery and Methods." By George A. Sherron, Eastern Manager, Koehring Machine Co., Philadelphia, Pa.

November Meeting—"Structural Engineering Problems in Electric Transmission Line Construction." By James S. Martin, Structural Engineer, Duquesne Light Co., Pittsburgh, Pa.

Respectfully submitted,

L. F. W. Hildner, *Chairman.*

REPORT OF MECHANICAL SECTION

To the Board of Direction,
Engineers' Society of Western Pennsylvania:

Dear Sirs:

I beg to submit the following report of work done by the Mechanical Section during the year 1920.

Five regular meetings of the Mechanical Section were held in 1920 with an average attendance of 77, the maximum attendance being 107 at the April meeting and the minimum 37 at the June meeting. The average number participating in the discussion of papers was six.

The papers presented are as follows:

February Third—"Powdered Coal." By John E. Muhlfeld, Vice President, Railway & Industrial Engineers, New York.

April Sixth—"Power Plant Meters and Instruments." By E. G. Bailey, President, Bailey Meter Co., Cleveland, O.

June First—"Status of Smoke Abatement." Osborn Monnett, Consulting Engineer, Chicago, Ill.

October Fifth—"Water Gas." By A. E. Blake, Sales Engineer, Surface Combustion Co., Pittsburgh.

December Seventh—"The Underfeed Stoker—Its History and Application." By Edward Rahm, Jr., Sales Engineer, Underfeed Stoker Co. of America, Pittsburgh.

Respectfully submitted,

George T. Ladd, *Chairman.*

REPORT OF METALLURGICAL AND MINING SECTION

To the Board of Direction,
Engineers' Society of Western Pennsylvania:

Dear Sirs:

I beg to submit the following report of the work done by the Metallurgical and Mining Section during the year 1920.

Three regular meetings of the Section were held in 1920 with an average attendance of 57, the maximum attendance being 68 at the March meeting, and the minimum 48 at the November meeting. The average number participating in the discussion of papers was six.

The papers presented were:

March Thirtieth—"Mine Hoisting—Duty Cycles." By M. A. Whiting, Engineering Dept., General Electric Co., Schenectady, N. Y.

October Twenty-sixth—"Sulphur In Coal and Coke." By Dr. A. R. Powell, Physical Organic Chemist, U. S. Bureau of Mines, Pittsburgh.

November Thirtieth—"Mineral Resources of Pennsylvania." By Dr. George W. Ashley, State Geologist, Harrisburg, Pa.

Respectfully submitted,

J. W. Paul, *Chairman.*

REPORT OF TELLERS

To the Members,
Engineers' Society of Western Pennsylvania:

Dear Sirs:

The undersigned tellers publicly canvassed the ballots in the annual election of officers of the Society at noon, Tuesday, January 18, 1921, and beg to report the following results:

Ballots received	369
Irregular ballots	7
Ballots counted	362

For President	George H. Danforth	361
For Vice President	Morris Knowles	359
For Trrasurer	A. Stucki	361
For Directors	L. F. W. Hildner	361
	G. T. Ladd	357

Respectfully submitted,

N. F. Hopkins, Chairman;
W. S. Church,
A S. Davison,
Tellers.

The President thereupon declared the following men elected:

For President	George H. Danforth
For Vice President	Morris Knowles
For Treasurer	A Stucki
For Directors	L. F. W. Hildner George T. Ladd

Before the new president was escorted to the chair, Mr. Hawley addressed the Society as follows:

Before taking up the subject which I have chosen for my address, I wish to review briefly some of the important questions now before our Society. From the Treasurer's report it is evident that it is only by the utmost economy that the Society will be able to keep its expenses within the amount of its receipts for the coming year. We were indeed fortunate that the membership dues were increased just before the war. The amount of the deficit for the past year is small and it was caused by the general increase in the costs of everything, particularly our bills for printing. It is hoped that these can be reduced and that with a material increase in membership which we have reason to expect, there may be a balance on the right side of the ledger for the coming year. Otherwise, it will be necessary to consider a slight increase in dues.

The Committee which has been considering the proposed "Associated Engineering Societies of Pittsburgh," Mr. Summer B. Ely, Chairman, has progressed with its work to a point where the regulations governing the Association have been approved by your Board of Direction and returned to the Committee for re-submission to the various societies that are to be the charter members of the Association. This question has been under consideration now for more than a year and has encountered the delays which must be expected in a matter in which so many different organizations have an interest. The preliminary draft of the Regulations was agreed to with minor changes by all the organizations to which it was submitted, except one. In this case a change in the personnel of the committee representing the organizations caused considerable delay and a misunderstanding of the proposed Regulations brought about an effort to make material changes after the Regulations had been accepted by all of the other Societies.

It is expected that in the near future the Regulations which have been approved by your Board of Direction and which differ in minor points from those originally submitted to the other Societies will be accepted by them and they will then be transmitted to the members of this Society for a letter ballot for decision as to whether or not this Society shall enter the proposed affiliation. As the plan has been worked out, the proposed affiliation is built up with this Society as the parent engineering Society and the nucleus of the organization.

Our Society also has before it the question of joining the Federated American Engineering Societies. The matter was discussed at a special meeting of the Society held on December 8, but the attendance at that meeting was small and the matter was referred back to the Board of Direction by that meeting to obtain additional information and to again present the matter to the Society.

A matter of vital importance to all engineers is the proposed licensing bill which is to be introduced at the present session of the Legislature at Harrisburg. A few years ago an effort was made to pass such a bill and hearings were had in various portions of the state, one of which was in

Pittsburgh. At that time the sentiment of the profession seemed to be overwhelmingly against the proposition to license engineers. In the meantime, similar bills have been enacted in several other states and there seems to have been a change in attitude on the part of some engineers toward such legislation. The bill now before the Legislature is one which should receive the careful consideration of all engineers, and if it is to be enacted into a law, its provisions should be based upon the best of the acts now in force in other states, and the experience which has been gained by their enforcement.

There is now under way the formation of two new sections of the Society, a Steel Works Section and a Practicing Engineers' Section, which should broaden the scope and increase the activities of the Society, and add materially to the membership.

The rooms of the Society are open during the daytime and until 10:00 P. M. each week-day for the use of our members. A large number of technical publications and current magazines are available for reading, and the rooms can be used for personal engagements, small committee meetings, etc., as are the rooms of a club. Very few of our members are taking advantage of this opportunity. The younger members especially, are missing an opportunity to keep in touch with the technical literature of the day and to make acquaintance and friends among the members of the profession. A half hour at lunch or an occasional evening spent in the Society Rooms will be well worth while.

The new officers and the Board of Direction of the Society face a difficult task in the management of its affairs for the coming year. I bespeak for them your hearty, active support and co-operation. In no way can your efforts be of more service than in securing new members. Let every member of the Society constitute himself a committee of one to secure a new member There are hundreds of men in the Pittsburgh District who ought to be, but are not members of the Society. Surely you know one of these. Hand him an application blank and don't stop there, but follow it up and see that the application is filled out and reaches the Board of Direction. The Board will do the rest.

In closing, I wish to express again my great appreciation of the honor which was conferred upon me by my election as President of the Society. I congratulate the new President and other officers and wish them the greatest success possible in the carrying on of the Society's business.

Mr. Hawley requested past presidents Neilson and Stucki to escort the president-elect to the Chair, who upon assuming the chair, addressed the Society as follows:

In accepting this honor that you have very kindly conferred upon me, I realize that I have also accepted a task of some magnitude. I had prepared a few words to say, based on the experience of the past year, but Mr. Hawley has so thoroughly set forth what I had in mind that I will not repeat them There is something, however, that I do wish to mention and that is to urge upon every member of the Society to feel perfectly free to make any suggestions, constructive criticisms or comments. In the years I have been a member of the Society, I have found that there is no means by which the officers can determine the desires or hopes of the individual members unless the members themselves come forward and present their case. It is really important that this be done for contact with the individual members must be maintained so that the Society may fulfill its proper function. Gentlemen, I thank you.

In accordance with announcement published in the notice of this meeting the recommendation that a Steel Works Section be formed in compliance with the following petition was presented:

To the Board of Direction,
Engineers' Society of Western Pennsylvania:

Dear Sirs:

The undersigned members of the Engineers' Society of Western Pennsylvania, believing that the objects of this Society can be materially furthered by the formation of a Steel Works Section, do hereby make formal application for the formation of such a Section as provided in the By-Laws of the Society.

Our Society exists in the heart of the greatest steel works section of the country, and it is believed that the Society can do much more towards filling its proper position in this community by including a Steel Works Section among its activities.

We sincerely trust that the formation of this Section will meet with your approval and that you will so report at the next meeting of the Society.

Yours very truly,

(Signed) W. E. Snyder
F. N. Speller
J. A. Hunter
C. W. Bennett
F. E. Leahy
W. P. Chandler, Jr.
T. P. Davies
A. N. Diehl
A. L. Hoerr
H. N. Pendleton
A. B. Holmes
G. H. Neilson
A. Stucki
G. H. Danforth

On motion of Mr. J. W. Paul, duly seconded and carried, it was ordered that a Steel Works Section be formed as recommended by the Board of Direction.

No further business coming before the Society, the retiring president's address was presented by Mr. W. C. Hawley, Chief Engineer and General Superintendent, Pennsylvania Water Company, Wilkinsburg, Pa., on "Some Problems Encountered in Water Works Engineering."

The ensuing discussion was participated in by G. E. Flanagan, Mech. Engr., Heyl & Patterson, Inc.

On motion the meeting adjourned at 10:05 P. M.

K. F. Treschow, *Secretary.*

METALLURGICAL AND MINING SECTION

The Annual Meeting of the Metallurgical and Mining Section of the Engineers' Society of Western Pennsylvania was held in the Palm Room, William Penn Hotel, Tuesday, January 25, at 8:30 P. M., Chairman J. W. Paul presiding, 22 members and visitors being present.

The Minutes of the last Annual Meeting held March 30, 1920, were read and approved.

The annual report of the Chairman was read by the Secretary.

The report of the Nominating Committee was presented by Mr. Harrop, Chairman:

To Officers and Members of Metallurgical and Mining Section,
Engineers' Society of Western Pennsylvania:

Dear Sirs:

Your Nominating Committee have selected the following gentlemen for the officers of the Section for the ensuing year:

J. D. Martin..Chairman
T. W. Dawson...Vice Chairman
H. H. Rankin
N. F. Hopkins
W. A. Weldin } ....Directors
J. S. McDowell
R. R. Hice

Respectfully submitted,

H. S. Harrop, Chairman;
W. A. Weldin
L. D. Tracy

Nominating Committee.

On motion the nominations were closed and the Secretary was requested to cast a unanimous ballot in favor of the election of the officers named, who were thereupon declared elected.

The Secretary presented the following petition, duly signed by five members of the Society, for an amendment to the By-Laws of the Section, to change the name of the Section, which on motion was approved and a letter ballot requested. Petition is as follows:

To Members of Metallurgical and Mining Section,
Engineers' Society of Western Pennsylvania:

Dear Sirs:

In accordance with Article 6 of the By-Laws of this Section the undersigned members do hereby propose an amendment to our By-Laws, changing the name of the Section from "Metallurgical and Mining Section" to "Mining Section," taking out the word Metallurgical.

This amendment is proposed in view of the fact that a "Steel Works Section" has just been formed, and it is believed that the Metallurgical work of the Society should be included in the work of the Steel Works Section rather than the Mining Section.

Respectfully submitted,

J. W. Paul
L. D. Tracy
H. S. Harrop
Viking Enebuske
A. C. Fieldner

BOARD OF DIRECTION

The regular monthly meeting of the Board of Direction of the Engineers' Society of Western Pennsylvania was held in the Society Rooms, Union Arcade Building, Thursday, February 3rd, at 4:15 P. M., President George H. Danforth presiding, Messrs. Spellmire, Schatz, Fohl, Hildner, Hunter, Martin, Blum, Hobbs, Ladd, Neilson, Hawley, and the Secretary being present.

The Minutes of the last meeting, held January 6th were read and approved.

The applications of the following gentlemen, having been regularly published to the Society pursuant to the action of the Board, were elected to membership:

MEMBERS

Brandt, C. A.
Durkee, J. O.
Jones, B. F.
Miller, J. F.

JUNIORS

Marshall, W. L.
Hayes, C. E.
Cook, E. C.

Applications were received from the following gentlemen and their names ordered published to the Society. Assignment to the various grades of membership is as follows:

MEMBERS

Clause, W. L.
Daubert, Charles W.
Hurlburt, Alfred
LeVally, John R.
Mueller, Edward O.
Murray, John J.
Rinehart, Edward E.
Toler, James Putnam

JUNIORS

Klingelhofer, Edward Kohne
Pettay, George Theodore

The Secretary presented a request from Mr. F. M. VanDeventer asking to be transferred to the grade of Junior. Mr. VanDeventer has been made an Associate Member due to his not being old enough for full membership and prefers to be classed as a Junior so that on reaching the proper age, he will be automatically transferred to the grade of member.

It was moved and carried that his name be transferred as requested.

The Secretary presented letters of resignation from the following gentlemen, which after discussion, were ordered accepted.

Ahlen, William
Clapp, F. G.
Dye, Ira
Knesche. Joseph A.
Lakey, Arthur B.
Leete, John H.
McCall, C. H.
Marcus, M. M.

The following resignations were received and were ordered held over until next meeting of the Board:

Gerber, Louis C.
Howarth, H. A. S.
Huntsman, Sr., R. C.
Knox, L. L.
Luce, W. A.
Paar, Oscar H.
Lincoln, P. M.
Shoemaker, L. H.
C. R.
Utley, J. C.
Wilcox, C. L.

The Secretary was requested to write those members who had moved away from Pittsburgh, calling their attention to non-resident dues, in an effort to secure the withdrawal of their resignations.

Due to change in Chairmen of the various Committees, the report of the Secretary was not checked by the new Committee and it was, therefore, held over until the March meeting.

COMMITTEE REPORTS

In the absence of Mr. James, Chairman of the Entertainment Committee, the Secretary reported a paid attendance at the Annual Dinner of 749, which makes total receipts of $5243.00, the total expenses were $4916.95, making a net profit of $326.05.

HOUSE COMMITTEE.

Mr. Schatz, Chairman of the House Committee, reported an evening attendance of 76 for the month of January.

PUBLICATION.

Mr. Spellmire, Chairman of the Publication Committee, reported that on Jan. 5th, a letter from Mr. Samuel E. Duff was submitted offering suggestions in regard to enlarging the size of our Proceedings, also other matters pertaining to our printing matter, and suggested that the Secretary arrive at an estimate covering total cost of changes suggested.

A copy of this letter was sent to members of the Board, inviting suggestions and criticism, to be addressed in writing to the Chairman of the publication Committee and after suggestions had been received and costs known, meeting of the Publication Committee would be held and recommendations made for the attention of the Board.

Four letters have been received, of a possible ten, and it was not deemed advisable to hold a meeting of the Committee. The Chairman suggested if there was time at the Board meeting, that members express themselves freely, so that the Secretary might take notes which could be used at the meeting of the Publication Committee, and considered with the written communications, which will expedite the handling of this business.

Papers have been provided for the meetings for the fiscal year of the Committee.

The Secretary presented a letter from Mr. Norman MacLeod, Executive Secretary European Relief Council, requesting that our Society appoint a committee to solicit funds for the work of the Council which is being aided by Mr. Hoover.

After considerable discussion, it was moved and carried that the Secretary be requested to write Mr. MacLeod, stating that while the Society was heartily in favor of the work being done by the Council and realizing the necessity of every one helping in this worthy cause, the Board did not feel, in view of the fact that probably all of our members had been solicited either through their companies or their homes, that the Society should form a committee as requested or go into the matter further.

The Secretary presented a letter from Mr. James O. Handy Chairman of the Public Library Committee of the American Chemical Society, requesting that the Society join the Committee of the Pittsburgh Section in asking the manufacturers of this district to jointly contribute $5000 annually for ten years to the Technology Dept. of the Carnegie Library. Mr. Handy pointed out that the City had appropriated enough to hold the present personnel of the Library, but not enough for the additional assistance needed for the increased cost of various books and journals, which are required and which were formerly furnished free of charge.

After discussion, it was moved and carried that the Secretary write Mr. Handy stating that while the Society realized the importance and need for these additions, the Board did not feel that it was a good time to collect such funds and further that this was purely a matter for action of the City Council and should be taken care of by them. The Board, however, would be willing to either appoint a committee or representatives from the Board to go before the City Council with a committee from the American Chemical Society, urging that this additional amount be appropriated.

The Secretary brought up the matter of the Associated Engineering Societies of Pittsburgh stating that the proposed Constitution had now been formally adopted by the Local Sections of the A. S. M. E., A. S. C. E. and A.I. E. E. and as this had been approved by the Board of Direction, the matter is now ready to go before the General Society for a vote.

After discussion, it was moved and carried that the Secretary be authorized to put this matter before the members for a letter ballot, sending out copies of the Constitution together with a note of explanation in regard to it.

The Secretary presented a letter from Mr. L. P. Alford, Temporary Secretary of the American Engineering Council, inviting this Society to attend a meeting of the Council to be held in the Technology Club, Syracuse, N. Y., on Feb. 14th. After discussion, it was moved and carried that the Secretary be requested to write Mr. W. A. James and Mr. J. H. Throm, members of the Society who reside in that vicinity asking that they attend this meeting as representatives of the Society if possible.

The Secretary then retired from the room while the election of a Secretary took place and Mr. K. F. Treschow was reelected with an increase of $25.00 per month.

The meeting adjourned at 5:20 P. M.

K. F. Treschow, *Secretary.*

SPECIAL MEETING
BOARD OF DIRECTION
February 17, 1921

A special meeting of the Board of Direction of the Engineers' Society of Western Pennsylvania was held in the Society Rooms, Union Arcade Bldg., Thursday, February 17th at 4:00 P. M. President George H. Danforth presiding, Messrs. James, Stucki, Hawley, Hildner, Martin, Blum, Ladd, and the Secretary being present. Mr. Samuel E. Duff and Harry J. Lewis were also present.

Mr. Danforth stated that the meeting had been called to consider House Bill No. 204, an Act licensing engineers in the State of Pennsylvania which had been presented to the House on Jan. 31st and referred to the Committee on Ways and Means on Feb. 1st.

Mr. Danforth also stated that he had learned that the Chairman of the Committee was Mr. Hugh Dawson, President of the Engineers' Society of Scranton, who was much interested in the Bill and proposed to see it acted upon as soon as possible. Mr. Danforth appointed Mr. Louis P. Blum a committee of one to go over the bill and make a report.

Mr. Blum had read over the Bill and made his report, copy of which is given below, which suggested certain changes and the special meeting was called to consider the report and Bill as a whole.

To the Board of Direction,
Engineers' Society of Western Pennsylvania.

Dear Sirs:

In accordance with the request of Mr. Treschow, the writer has examined Act No. 204, file of the House of Representatives of Pennsylvania Session of 1921, the purpose of which is to regulate the practice of professional engineering and land surveying in the State of Pennsylvania. As stated at a recent meeting of the Board of Direction the writer considers this matter of extreme importance.

The matter of licensing engineers has been under discussion for some years. You will recall that about six or eight years ago, the Engineers' Society of Western Pennsylvania acted adversely upon a bill then before the State Legislature. Since then, conditions in this respect have changed. Most of the provinces of the Dominion of Canada and many of the States in the United States have passed licensing laws. Engineering Council has considered the subject and recommended a form of law to be adapted to the various states. Other engineering organizations have considered this subject and at the present time the Pittsburgh Section of the American Society of Civil Engineers, The Association of Engineers in Private Practice and the American Association of Engineers are considering the bill now in the State Legislature. Possibly the local section of the American Society of Mechanical Engineers are considering the same subject.

The Bill before the Legislature is modeled in general upon the lines recommended for legislation by the Engineering Council. It seeks to regulate the practice of land surveying and professional engineering in Pennsylvania by compelling the licensing of all engineers in responsible charge of engineering practice in the State.

The principal objection which has been raised to the Bill in its present form occurs to the writer as a very proper one. Section 4 prescribing the character of the State Board for registration does not seem to be rigid enough in requirements for membership on this Board. Naturally, in carrying out the provisions of a law of this kind, legislation must be general and it must be left to the discretion of the Board of Registration. They must study the conditions of the profession, must prescribe the qualifications for registration and it is essential that, as such registration lies at the foundation of the practice of the profession and affects the body of engineers as well as the life of every individual engineer, such Board shall be composed of men of the highest attainments and character. The Law as proposed states that six members of the Board of seven shall be professional engineers. Why should not seven of the seven be so qualified? What is an engineer? The Act in its entirety seeks to place no definition upon the engineer. It defines "land surveying," it defines "Board," but it fails to define the engineer. The writer recognizes the difficulty of defining the term, engineer, but if the engineers of the state cannot define the word, how can we expect the Governor or the judiciary to define it.

Under Secton 4, as stated, it would be possible for the Governor to appoint six members of the Board simply on their own statement that they are professional engineers, except that they shall be engaged in practice for ten years, responsible charge of work for five years and a member of a recognized society. The writer suggests that the following clause be inserted in Section 4.—"The members of the Board shall be members of recognized standing in the profession; not less than one and not more than two members of the Board to be appointed from practitioners in each of the following branches of engineering—civil, mechanical, electrical and mining engineering and land surveying. No engineer in state, county, city or borough service shall be eligible to appointment on said Board." The writer thinks that the last clause, while less important than the first, is necessary in order to remove the Board from political control as thoroughly as possible.

It seems to the writer that this is the most necessary amendment to the proposed law. Other matters may be left for compromise or negotiation, but if the practice of engineering is to be controlled by a Board of Registration, the Board should be composed in such a way as to commend the respect and support of the engineers of the State.

All other criticisms which the writer makes are subordinate to the main criticism.

Section 12. The writer questions, in view of the experience of other engineering organizations, whether the Secretary should be a member of the Board. Experience leads to the belief that a non-technical secretary in charge of the administrative work will produce better results than a technical secretary member of the Board and especially is this section open to criticism in stating on page 6, line 2, that a quorum of the Board shall consist of not less than two engineers and the Secretary. In other words, the absence of the Secretary, through illness or other cause, makes it impossible for the Board to function.

Section 18—line 18. The writer cannot see any reason why a declaration of intention to become a citizen of the United States would be sufficient to make an engineer eligible for registration. The declaration is not always followed by naturalization and the writer believes that registration should be limited to those who are citizens of the United States or Canada.

Section 19—paragraphs a and b. Should, in the writer's opinion, be amended to add at the end of each the following clause—"At least one year of which shall have been in responsible charge."

Section 23, paragraph G—page 12. The writer believes that this section should be amended so as to make this Act effective in all the departments of the Commonwealth of Pennsylvania or political sub-division within a period of five years after the date of passage of the Act.

Section 26—line 25. The writer suggests that the word "May" should be changed to "must." If registration is worth while, the public are entitled to know beyond doubt whether they are dealing with a registered engineer or not.

Section 29 page 16,—line 9. The writer believes that there are certain portions of the profession of engineering which should be closed to the architect and that certain portions of architecture should in turn be closed to the engineer.

Respectfully yours,
(Signed) Louis P. Blum.

Mr. Danforth then asked for the opinion of the Board as to whether or not in their opinion there should be any act licensing engineers in Pennsylvania.

After a general discussion, it was found that the opinion of those present, while divided on the question of the necessity of state lgislation, strongly favored action by the Society along most effective lines to prevent the passing of an absolutely improper and unjust law.

After a general discussion of Mr. Blum's report it was moved and carried that the President appoint a committee to put into shape the suggestions of amendments as discussed at the meeting using Mr. Blum's report as a basis and further that this Committee meet with Mr. Dawson, Chairman of the Committee on Ways and Means, who, it is understood, will be in Pittsburgh Friday, Feb. 18th, to ascertain the status of the Bill; discuss details of it with him; and suggest the above mentioned changes.

Mr. Danforth then appointed the following committee:

Samuel E. Duff	Louis P. Blum
Harry J. Lewis	W. C. Hawley

The President requested the Secretary to get in touch with Mr. Dawson immediately by 'phone and arrange a meeting with him to meet the Committee sometime Friday.

The meeting adjourned at 5:30 P. M.

K. F. TRESCHOW, *Secretary.*

MECHANICAL SECTION

The Annual Meeting of the Mechanical Section of the Engineers' Society of Western Pennsylvania was held in the Palm Room, William Penn Hotel, Tuesday, February 1st, at 8:15 P. M., Chairman George T. Ladd presiding, 105 members and visitors being present.

The Minutes of the last Annual Meeting were read and approved.

The Annual Report of the Chairman was read by the Secretary.

The report of the Nominating Committee was read by the Secretary in the absence of Mr. Frohrieb, Chairman.

Officers and Members of Mechanical Section
Engineers' Society of Western Pennsylvania.
Dear Sirs:

Your Nominating Committee has appointed the following nomniees for the several officers of the Section for the ensuing year:

Chairman..J. C. Hobbs
Vice Chairman..................................W. E. Moore
Directors..................................E. P. Dandridge
J. I. Thompson
P. C. Patterson
L. Iverson
J. H. Fox

Respectfully submitted,
L. C. Frohrieb, Chairman
A. F. Backlin
W. E. Moore, Tellers.

On motion the nominations were closed and the Secretary instructed to cast a unanimous ballot in favor of the officers named and they were, therefore, declared elected.

There being no further business, the meeting adjourned and the regular bi-monthly meeting was called to order by Mr. J. C. Hobbs, the new Chairman.

There being no further business, the address of the retiring Chairman was presented by Mr. George T. Ladd on "A Description of the Large Boilers Operating at the River Rouge Plant of the Ford Motor Co." In addition to Mr. Ladds paper, Mr. E. C. Keithley, Engineering Dept. Locomotive Superheater Co., New York City, presented a paper, describing the superheating element of the plant and Mr. H. D. Savage, Combustion Engineering Corp., New York City, presented a paper on the coal pulverizing element of the plant.

The ensuing discussion was participated in by: C. F. Freeman, Sales Engr., Surface Combustion Co.; W. C. Buell, Jr., Chf. Engr., Liquid Fuel Dept., George J. Hagan Co.; S. G. Brigel Mgr., Economy Burner & Engineering Co.; F. J. Crolius, Steam Engr., Homestead Steel Works, Carnegie Steel Co.; J. R. Mason, Dist. Sales Mgr., The Wickes Boiler Co.; T. A. Peebles, Chf. Engr., The Hagan Corporation; K. L. Kortland, Designing Engr., Duquesne Works, Carnegie Steel Co.; Calvin W. Rice, Secy., American Society of Mechanical Engineers, New York City; J. C. Hobbs, Asst. to Supt. Power Stations, Duquesne Light Co.; and the authors, Mr. G. T. Ladd, Mr. E. C. Keithley and Mr. H. D. Savage.

Mr. Rice made a motion that a vote of thanks be extended to the authors of the three papers, which motion was corrected to extend it to Mr. Keithley and Mr. Savage, as according to the By-Laws a vote of thanks cannot be extended to a member. The corrected motion was seconded and carried unanimously.

No motion the meeting adjourned at 10:10 P. M.

K. F. Treschow, *Secretary.*

REGULAR MONTHLY MEETING

The 392nd meeting of the Engineers' Society of Western Pennsylvania was held in the Palm Room, William Penn Hotel, Tuesday, Feb. 15th, at 8:07 P. M., President George H. Danforth presiding, 82 members and visitors being present.

The Minutes of the last meeting were read and approved.

The Board of direction reported the election of four applicants to the grade of Member, and three to the grade of Junior and the receipt of ten applications for membership. Also the transfer of one member to the grade of Junior and the receipt of nineteen resignations, eight of which were ordered accepted and eleven held over until the next meeting of the Board.

The matter of the formation of a new section of the Society to be known as the "Practising Engineers' Section," having been published to the Society in accordance with the By-Laws, was brought up for action, whereupon on motion of Mr. H. D. James, duly seconded and carried, it was ordered that such a section be formed. The petition is as given below:

To the Board of Direction
Engineers' Society of Western Pennsylvania.

Dear Sirs:

The undersigned members of the Engineers' Society of Western Pennsylvania, believing that the objects of this Society can be materially furthered by forming a Practising Engineers' Section of the Society, do hereby make formal application for the formation of such a section as provided in the By Laws of the Society.

A number of practising engineers in this district recently formed an organization known as the Association of Practising Engineers and it was found that of a membership of forty or fifty, only ten or twelve were members of the Engineers' Society of Western Pennsylvania.

This organization voted, at its last meeting, to apply for admission to our Society in a body in accordance with a special invitation issued by the Board of Direction at its last meeting and it is felt that this Section should be formed at once, in order that our Society may be in a position to carry on the work started by the Association of Practising Engineers:

We sincerely trust that the formation of this Section will meet with your approval and that you will so report at the next regular meeting of the Society.

Yours truly,
F. G. Ross
B. L. Skinner
W. A. Weldin
J. M. Rice
Morris Knowles
M. R. Scharff
C. M. Reppert
W. M. Judd
A. E. Duckham
N. F. Hopkins
G. H. Danforth
L. P. Blum.

There being no further business before the Section, the paper of the evening on "Some Methods of Obtaining Adjustable Speed with Electically Driven Mills" was presented by Mr. K. A. Pauly, Power & Mining Engineering Dept., General Electric Co., Schenectady, N. Y.

The ensuing discussion was participated in by; G. E. Stoltz, Gen. Engr., Westinghouse Elec. & Mfg. Co.; M. P. Clark, Engr. Expediter, National Tube Co.; F. M. VanDeventer, Engr., National Tube Co.; Barton R. Shover, Cons. Electrical Engr., Pittsburgh, and the author.

It was moved and carried that a vote of thanks be extended to Mr. Pauly for his very excellent paper.

On motion the meeting adjourned at 10:07 P. M.

K. F. Treschow, *Secretary.*

ORGANIZATION MEETING

Steel Works Section

The organization meeting of the Steel Works Section of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Monday evening, February 28th, at 8:15 P. M., President George H. Danforth presiding, 94 members and visitors being present.

On motion the President was authorized to appoint a Nominating Committee for the nomination of officers for the Section and appointed Mr. A. L. Hoerr, Chairman, W. P. Chandler, Jr., and Mr. A. E. Blake, with the request that they report later in the evening.

The next business of the meeting was the appointment of a committee to draft a Constitution and By-Laws for the Section and the President authorized Mr. H. M. Eastman, Chairman, and Mr. A. L. Hoerr and Mr. G. E. Flanagan to serve on this committee.

There being no further business, the paper of the evening on Distribution and Use of Coke Oven Gas was presented by Mr. Strickland Kneass, Jr., Steam Engineer, Youngstown Sheet & Tube Co., Youngstown, O.

Before discussion of the paper, the Nominating Committee presented their report as follows:

T. P. Davies, Chairman
Strickland Kneass, Jr., Vice Chairman

W. C. Coryell O. E. Gressly G. D. Bradshaw G. M. Goodspeed Frank E. Leahy	Directors

There being no further nominations, on motion the Secretary was instructed to cast a unanimous ballot of the members present in favor of the election of the persons nominated, who were thereupon declared elected.

Vice Chairman Kneass took the chair in the absence of the Chairman, and expressed his appreciation of his election to office.

The Secretary then declared the paper open for discussion. The ensuing discussion was participated in by: W. M. Flanagan, Steam Engr., Ohio Works, Carnegie Steel Co.. Youngstown, O.; W. C. Buell, Jr., Chf. Engr., Liquid Fuel Dept., George J. Hagan Co.; Frank E. Leahy, Steam and Expr. Engr., Carnegie Steel Co., Duquesne, Pa.; Franklin H. Smith, National Tube Co.; W. P. Chandler, Jr., Asst. Expr. Engr., Carnegie Steel Co., Duquesne, Pa.; E. O. Mueller, Engr., Gas Producer Dept., George J. Hagan Co., and the author.

On motion the meeting adjourned at 9:25 P. M.

K. F. TRESCHOW, *Secretary.*

BOARD OF DIRECTION.

The regular monthly meeting of the Board of Direction of the Engineers' Society of Western Pennsylvania was held in the Society Rooms, Union Arcade Bldg., Thursday, April 7th, at 4:10 P. M. President George H. Danforth presiding, Messrs. James, Knowles, Schatz, Spellmire, Hildner, Davis, Blum, Long, Neilson, Hawley and the Secretary being present.

The Minutes of the last meeting were read and approved.

The applications of the following gentlemen, having been regularly published to the Society pursuant to the action of the Board were elected to membership.

MEMBERS.

Bayne, R.
Bell, G. G.
Burns, S. H.
Cook, J. H.
Cooper, F. M.
Dignan, G. E.
Frease, J. B.
Hess, O. P.
Hess, E. W.
Hill, F. L.
Hinnau, W.
Hirtle, Wm. A.
Iiams, E. J.
Jacobs, N. B.
Kerr, B. A.
Kramer, F. P.
Lippincott, H. C.
Long, C. E.
Malady, J. A.
Martin, P. H.
Matheson, C. P.
Miller, C. E.
Morton, J. A.
Moyer, F. H.
McGovern, T. J.
McKinney, C. R.
McKinney, R. M.
McMullin, P. S.
Schneider, R. A.
Shaw, A. G.
Siefers, G.
Smith, R. L.
Smith, W. W.
Stone, C. E.
Wakefield, W. S.
Wallis, Wm. B.
Weimer, W. G.
Wilcox, E. A.
Wyant, F. A.

ASSOCIATE MEMBERS.

Jacques, F. E.
Butler, R. E.

Applications for membership were received from the following gentlemen and their names ordered published to the Society. Assignment to the various grades of membership is as follows:

Andrews, R. W.
Angstrom, C. J.
Bell, F. B.
Bennett, R. H.
Black, R. M.
Bushnell, C. D.

Carlock, J. B.
Chester, T.
Kohler, D. S.
Markhart, C. O.
Martin, R. L.
Maxfield, H. H.
Merten, W. J.
Moore, M. M.
McClane, W. H.
Clark, C. H.
Collord, G. L.
Cook, T. R.
Danks, A. C.
Davis, C. S.
DeVou, J. L.
Eaton, S. M.
Ellers, K. F.
Forsberg, R.
Gillies, W. F.
Gleason, D. T.
Grabe, C G.
Guthrie, B.
Haller, H. E.
Hartzell, E. F.
Haydock, W.
Heller, L. W.
Hertzler, S. P.
Holmes, A. G.
Hughes, G. W.
Hughes, H. H.
Jones, A.
Keenan A. W.
McDaniels, B. P.
Page, G. B.
Peebles, T. A.
Pohlman, A.
Robbins, C.
Robinson, Wm. R.
Ryan, J. T.
Schmidt, O. DeC.
Schultz, A. L.
Shover, B. R.
Stang, A. H.
Stickle, H. W.
Streeter, R. L.
Werth, J. R.
Williams, D. C.
Williams, E. H.
Yardley, J. L. McK.
Zwally, E. L.

ASSOCIATE MEMBERS.

Banks, R. H.
Bucher, H. F.
Bullington, L. C.
Cogswell, F. R.
Dann, Alex. W.
Edgar, W. C.
Espenschied, F. F.
Fatkin, E. S.
Goodwin, W. C.
Graybill, J. H.
Haas, C.
Hopwood, J. M.
Howard, J. G.
Hussey, R. M.
Kaiser, B. J.
Keogh, J. K.
Line, J. D.
Lyon, J. F.
Nyman, A.
Oseroff, D. M.
Plapp, E. B.
Rew, F. A.
Reynolds, A. N.
Schmertz, W. E.
Smith, H. W.
Snyder, J. C.
Stehman, E. H.
Stuckeman H. S.
Thompson, D. D.
Tafel, T. Jr.
Walker, G. J.
Whiteman, C. A.

JUNIORS.

Allison, J. H.
Feledy, C. F.
Boyle, W. W.
Eastwood, S. K.

Hass, S. G.
Karn, F. S.
Kelly, J. M.
Donahue, J. G. Jr.
McVetty, P. G.
Schwartzman L. J.
Slicer, H. T.
Swift, H. L.
Tyler, C. M.
Williams S. V.

Requests were received from the following gentlemen that they be transferred to the grade of Member. After discussion the Secretary was requested to write these gentlemen advising them that they have been transferred as requested.

Whited, E. W.
Norris, E. W.
Kneass, S., Jr.
Chandler, W. P., Jr.

Letters of resignation were received from the following and after discussion they were ordered accepted.

Louis C. Gerber, Joined July, 1910.
H. M. Hooker, Joined June, 1913.

The Secretary reported the death of the following gentlemen.

John McGinley
E. F. Wood.

The report of the Secretary showing the financial condition of the Society at the close of business Feb. 28th, having been previously audited by the Finance Committee, was approved.

Mr. Spellmire, Chairman of the Entertainment Committee, reported a successful and well attended trip to the Colfax Plant of the Duquesne Light Co. on April 2nd in compliance with invitation from Mr. Thompson on the occasion of our Annual Banquet.

He also stated that arrangements had been made for an inspection trip to the plant of the Beech Bottom Power Co. near Wellsburg, W. Va., on May 7th, also one to the plant of the American Window Glass Co., May 21st or 28th.

An effort is also being made for a dinner-dance at the William Penn or the Ft. Pitt Hotel in the near future. This will be supplemented by motion pictures. Details announced later.

There were three or four other inspection trips to be held, but on account of depression in business, the plants are shut down.

In the absence of Mr. Fohl, Chairman of the Finance Committee, the Secretary reported that Mr. Fohl had appointed Mr. E. J. Deckman and Mr. Sydney Dillon as members of the Finance Committee.

The Committee held one meeting during the past month at which the report of the Secretary for the month of February was audited and found correct. Several matters were taken up and the committee expects to make a report at the next meeting of the Board.

Mr. Schatz, Chairman of the House Committee, reported an evening attendance of 62 for the month of March.

He also reported that the Committee had under consideration the matter of Society quarters and is looking into several prospects brought to their attention.

It was also thought advisable to purchase an additional chess table for the Club Rooms.

Mr. M. R. Scharff and F. N. Speller have been appointed as members of the Committee for the ensuing year.

In the absence of Mr. Hunter, Chairman of the Membership Committee, the Secretary reported stating that a meeting had been called for Friday, April 8th, but due to the illness of Mr. Hunter, it had been postponed.

Eighty-six acceptances have been received of the 500 letters sent out to the National Society members residing in this district inviting them to join the Society without filling out an application blank, also without the payment of the usual entrance fee.

The committee expects to develop other plans for increasing the membership this Spring and Fall.

Mr. Hildner, Chairman of the Publication Committee, reported the appointment of the following members on the Committee:

Affelder, L. J.
Baker, G. M.
Blake, A. E.
Blum, L. P.
Braden, E. V.
Covell, V. R.
Davies, T. P.
Eavenson, H. N.
Gisin, C. H.
Hobbs, J. C.
Long, C. E.
Martin, J. D.
Rott, W. C.
Thompson, J. I.

The Committee also had under consideration the matter of reducing cost of printing our proceedings, calling in eleven Pittsburgh printers, one in Chicago and one in Battle Creek. The Secretary also took a trip to Philadelphia to secure bids from six or eight printers there.

Prices ranged from $4.00 to $9.10 per page, the lowest bid being received from our present printer. In conferring with our present printer, he found it possible, due to drop in price of paper, to lower his price to $3.75 per page and the Committee recommends that we award the contract to the James McMillin Printing Co.

The Secretary submitted the following report by Mr. Harry J. Lewis, who with Mr. P. H. Martin, represented the Society at the hearings held in connection with House Bill No. 204, an Act licensing engineers in the State of Pennsylvania. It was moved and carried that the report be received and filed.

To the Board of Direction,
Engineers' Society of Western Pennsylvania.
Dear Sirs:

In accordance with the request from President George H. Danforth, the writer and Mr. P. H. Martin acted as representatives of this Society at two public hearings at Harrisburg on Wednesday, March 23rd and Wednesday, March 30th, in connection with the proposed Act licensing engineers in the State of Pennsylvania.

Conferences were held before both of these meetings at which representatives from the Engineers' Club of Philadelphia, American Association of Engineers and other engineering organizations throughout the state were present.

The amendments recommended by the Board of Direction were presented at these conferences and it was found that in general, our suggested amendments and those of Mr. Humphrey, representing the Philadelphia engineers, were identical, the only difference being that the Philadelphia engineers had gone more in detail in making their amendments; whereas we had merely suggested changes which were important to the principle of the bill.

The opinion seemed to prevail at the last hearing that this bill would be amended along the lines suggested by Mr. Humphrey, but that it did not stand much chance of being passed at this Session of the Legislature, due to the fact that this Legislature adjourns on April 7th, which would not allow for reprinting of the Bill nor for its presentation as there are a great many Bills which would naturally take precedence over this one.

Respectfully submitted,

Harry J. Lewis.

The Secretary read a letter from Mr. R. J. Alderdice, Director Dept. of Public Safety, City of Pittsburgh in regard to Parking in the downtown district. After discussion it was moved and carried that the letter be referred to the Civic Affairs Committee with the request that they report back to the Board at the next meeting.

The Secretary presented a letter from the Secretary of the Board of Trustees, Pennsylvania State College, asking that this Society appoint delegates for the election of trustees at the meeting held June 14th.

It was moved and carried that the Secretary endeavor to secure some members of the Society who graduated from State College to represent us.

Mr. Blum brought up the matter of the appointment of Mr. N. F. Brown as head of the Dept. of Public Works and Mr. C. M. Reppert as Chief Engineer of the Bureau of Engineering, stating that he felt our Society should commend the Mayor on these appointments.

After discussion, it was moved and carried that a resolution to this effect be drawn up in the form of a letter and submitted to the Mayor. Mr. Danforth appointed Mr. Neilson and Mr. James to draw up this letter.

The Secretary presented a letter from Mr. A. D. Flinn, V. P., Div. of Engineering, National Research Council in regard to the compilation and publishing of a table of physical and chemical constants asking that our Society endorse the project.

After discussion, it was moved and carried that the Society endorse the publishing of these tables and that notice be sent to Mr. Flinn to this effect.

The Secretary presented a letter from Mr. Albert Shiels, V. P. of the Inter-Racial Council in regard to the Immigration Bills. After discussion it was moved that the letter be tabled.

On motion the meeting adjourned at 5:20 P. M..

K. F. TRESCHOW, *Secretary*.

MECHANICAL SECTION.

The regular bi-monthly meeting of the Mechanical Section of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday, April 5th, at 8:15 P. M. B. A. Ludgate acting as Chairman in the absence of the Chairman, J. C. Hobbs, 62 members and visitors being present.

The minutes of the last meeting held February 1st, were read and approved.

No further business coming before the Section, the paper of the evening on "Explosion Hazards in Industrial Plants Due to the Use of Pulverized Coal" was presented by Mr. L. D. Tracy, U. S. Bureau of Mines, Pittsburgh, Pa.

Written discussion was received from the following: Harvey Allen, Efficiency Engr, Pressed Steel Car Co., McKees Rocks, Pa; W. Greenwood, Safety Engr, Carnegie Steel Co., Youngstown, O.

The ensuing discussion was participated in by: Harvey Allen, Efficiency Engr., Pressed Steel Car Co.; J. R. Cline, Mill Practice Man, Universal Portland Cement Co., Universal, Pa.; W. Greenwood, Safety Engr., Carnegie Steel Co., Youngstown, O.; L. W. Marso, Quigley Furnace Specialties Co., New York, N. Y.; W. O. Renkin, Mgr., Engineering Dept., Quigley Furnace Specialties Co.; and the author.

On motion the meeting adjourned at 10:10 P. M.

K. F. TRESCHOW, *Secretary*.

REGULAR MONTHLY MEETING.

The 394th meeting of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday, April 19th, at 8:15 P. M. President George H. Danforth presiding, 81 members and visitors being present.

The Minutes of the last meeting were read and approved.

The Board of Direction reported the election of thirty-nine applicants to the grade of Member and two to the grade of Associate Member; the receipt of forty A. S. M. E., twenty-two A. I. E. E., twelve A. S. C. E. and 12 A. I. M. & M. E. local members of the National Societies and seventeen regular applications for membership and the receipt of two resignations.

No further business coming before the Society, the paper of the evening was presented on "The Erection of Steel Structures by Arc Welding" by M. J. R. Buchanan in the absence of Mr. H. L. Unland the author.

The ensuing discussion was participated in by: A. M. Candy, Gen. Engr., Westinghouse Elec. & Mfg. Co.; Thomas Chester, Dist. Mgr., American Blower Co.; O. H. Eschholz, Engr., Westinghouse Elec. & Mfg. Co.; Edward Godfrey, Struct. Engr., Robert W. Hunt & Co.; F. G. Hagar, Draftsman, Keystone Works, Jones & Laughlin Steel Co.; C. N. Haggart, Struct. Engr., Pittsburgh, Pa.;P. C. Merz, Cone. Engr., Youngstown, O.; E. W. Pittman, Gen. Mgr. & Engr. Works Repr., Dravo Contracting Co.; H. S. Sanford, Acting Gen. Mgr., Riter-Conley Mfg. Co.; H. P. Smith, Engr., Emsworth, Pa.; Walter B. Spellmire, Mgr., General Electric Co. and Mr. Buchanan for the author.

On motion duly seconded and carried, a vote of thanks was extended to Mr. Unland for his very excellent paper and to Mr. Buchanan for his kindness in reading it.

On motion the meeting adjourned at 9:35 P. M.

K. F. Treschow, *Secretary.*

JOINT MEETING STEEL WORKS SECTION AND PITTSBURGH SECTION, A. S. M. E.

The joint meeting of the Steel Works Section of the Engineers Society of Western Pennsylvania and the Pittsburgh Section of the American Society of Mechanical Engnieers was held on Tuesday, April 26th in the Blue Room, William Penn Hotel, at 8:15 P. M. Chairman T. P. Davies presiding, 126 members and visitors being present.

The minutes of the last meeting were read and approved.

The Committee appointed to draw up the By Laws of the Section reported through the Chairman, H. M. Eastman.

On motion duly seconded and passed, the report of the Committee or By Laws was adopted.

There being no further business, the paper of the evening was presented by Mr. Sumner B. Ely, Visiting Professor, Mechanical Engineering Dept., Carnegie Institute of Technology, Pittsburgh, Pa., on "Possibilities of Improved Methods of Rolling Sheet Steel."

The ensuing discussion was participated in by: C. W. Bennett, Asst. to Pres., American Sheet & Tin Plate Co.; G. H. Cole, Elec. Engr., Material & Process Engineering Dept., Westinghouse Elec. & Mfg. Co.; A. Pinkerton, Elec. Engr., American Sheet & Tin Plate Co.

Motion pictures were then shown of the Gary and Vandergrift Plants of the American Sheet & Tin Plate Co. by Mr. D. M. Buck of that company.

On motion, duly seconded and passed, a vote of thanks was extended to Mr. Buck for his courtesy in showing the pictures.

On motion the meeting adjourned at 10:10 P. M.

K. F. Treschow, *Secretary.*

BOARD OF DIRECTION.

The regular monthly meetings of the Board of Direction of the Engineers' Society of Western Pennsylvania was held in the Society Rooms, Union Arcade Bldg., Thursday, May 5th, at 4:15 P. M. President George H. Danforth presiding, Messrs. James, Knowles, Stucki, Spellmire, Schatz, Neilson, Hawley, Blum, Hobbs, Long and the Secretary being present.

The Minutes of the last meeting held April 7th, were read and approved.

The applications of the following gentlemen, having been regularly published to the Society pursuant to the action of the Board, were elected to membership.

MEMBERS.

Andrews, R. W.
Angstrom, C. J.
Bell, F. B.
Bennett, R. H.
Black, R. M.
Bushnell, C. D.
Carlock, J. B.
Chester, T.
Clark, C. H.
Collord, G. L.
Cook, T. R.
Danks, A. C.
Davis, C. S.
deVou, J. L.
Eaton, G. M.
Elers, K. F.
Forsberg, R. P.
Gillies W. F.
Grabe, C. G.
Guthrie, B.
Haller, H. E.
Hartzell, E. F.
Haydock, W.
Heller, L. W.
Hertzler, S. P.
Holmes, A. G.
Hughes, G. W.
Hughes, H. H.
Jones, A.
Keenan, A. W
Kohler, D. S.
Markhart, C. O.
Martin, R. L.
Maxfield, H. H.
Marten, W. J.
Moore, M. M.
McClane, W. H.
McDaniel, B. P.
Page, G. B.
Peebles, T. A.
Robbins, C.
Robinson, W. R.
Pohlman, A.
Ryan, J. T.
Schmidt, O. de C.
Shover, B. R.
Stang, A. H.
Stickle, H. W.
Streeter, R. L.
Werth, J. R.
Williams, D. C.
Williams, E. H.
Yardley, J. L. McK.
Zwally, E. L.

ASSOCIATE MEMBERS.

Banks, R. H.
Bullington, L. C.
Bucher, H. F.
Cogswell, F. R.

Damm, A. W.
Edgar, W. C.
Espenschied, F. F.
Fatkin, E. S.
Goodwin, W. C.
Graybill, J. H.
Haas, C.
Hopwood, J. M.
Howard, J. G.
Lyon, J. F.
Nyman, A.
Oseroff, D. M.
Plapp, E. B.
Rew, F. A.
Reynolds, A. N.
Schultz, A. L.
Schmertz, W. E.
Smith, H. W.
Snyder, J. C.
Stehman, E. H.
Stuckeman, H. M.
Tafel, T. Jr.
Hussey, R. M.
Kaiser, B. J.
Keogh, J. K.
Line, J. D.
Thompson, D. D.
Walker, G. J.
Whiteman, C. A.

JUNIORS.

Allison, J. H.
Boyle, W. W.
Donahue, J. G., Jr.
Feledy, C. F.
Eastwood, S. K.
Haas, S. G.
Karn, F. S.
Kelly, J. M.
McVetty, P. G.
Schwartzman, L. J.
Slicer, H. T.
Swift, H. L.
Williams, S.

The applications from the following gentlemen were received and their names ordered published to the Society. Assignment to the various grades of membership is as follows:

MEMBERS.

Andrews, W. W.
Crane, J. B.
Dunham, B. W.
Haslam, E. E.
Johnson, S. M.
McCabe, H. D.
McKnight, W. E.
Murphy, G. F.
Uhlenhaut, F. Jr.

ASSOCIATES.

Orr, N. H.
Shaw, H. C.

Letter of resignation was received from Mr. Cadwallader Evans, Jr., and after discussion, it was ordered accepted.

The Secretary reported the death of the following gentlemen:

W. G. Wilkins.
G. H. Barbour.

The Secretary was requested to secure a Memoir of Mr. W. G. Wilkins from Mr. George S. Davison and of Mr. Barbour from Mr. George H. Clapp.

The report of the Secretary showing the financial condition of the Society at the close of business March 31st, having been previously audited by the Finance Committee, was approved.

Mr. Spellmire, Chairman of the Entertainment Committee, reported that definite plans had been made for an inspection trip to the Beech Bottom Power Company's plant near Wellsburg, W. Va., on June 4th. The plan contemplates inviting the members of the local branches of the American Inst. of Electrical Engineers and the Association of Iron & Steel Electrical Engineers as our guests. Plans have also been made for a boat excursion in June, the exact date of which has not been determined.

In the absence of Mr. Fohl, Chairman of the Finance Committee, the Secretary reported verbally stating that the Committee had held a meeting at which the Secretary's report for March 31st was audited and approved.

The Committee has under consideration the matter of the general financial condition of the Society and contemplates a joint meeting of their committee with the House Committee in the near future, with reference to quarters for the Society. They are also endeavoring to find ways and means of reducing our expenditures and increasing our receipts.

The Schatz, Chairman of the House Committee, reported an evening attendance of 65 for the month of April. The Committee has held one meeting during the past month at which matters of Society quarters were taken up and discussed. The Committee called on Mr. Terry, Secy. Chamber of Commerce in regard to the possibility of our effecting an arrangement with them, also Mr. Shaw, Renting Agent of the Frick Estate in reference to renewing our present lease and the increase it would be necessary to pay under the new lease.

The Committee hopes to have a definite report on this matter for the Board within a short time.

In the absence of Mr. Hunter, Chairman of the Membership Committee, the Secretary reported verbally stating that the Committee had held one meeting during the past month at which several plans for increasing our membership were suggested and discussed.

The Committee felt, however, in view of the general business depression that it would be better to complete plans for a membership campaign to begin in September, rather than attempt any active work this Spring or Summer.

In the absence of the Chairman of the Publication Committee, Mr. Hildner, the Secretary reported verbally. stating that the Committee had under consideration the program for the coming year and had already scheduled papers and are to hold a meeting in the near future to complete the program.

The Secretary read the following resolution drawn up by Messrs. Neilson and James in accordance with the action of the Board at its last meeting, copy of which was sent to Mayor Babcock. It was moved and carried that the resolution be endorsed.

"WHEREAS: It has come to our attention that the vacancy existing in the Department of Public Works and the Bureau of Engineering have been filled.

THEREFORE BE IT RESOLVED: That the Directors of the Engineers' Society of Western Pennsylvania in regular meeting assembled, desire to commend the appointment by Mayor Babcock, of Mr. N. F. Brown as Director of the Department of Public Works and Mr. C. N. Reppert as Chief Engineer of the Bureau of Engineering. Inasmuch as both appointees are engineers of high standing, it assures the tax payers that the appropriations made for public work will be well and economically spent.

RESOLVED FURTHER, That a copy of these resolutions be sent to Mayor Babcock and that they also be spread on the Minutes of this Society."

The Secretary presented a letter from Dr. George H. Ashley, State Geologist of Pennsylvania, in regard to changing all scales of the Standard Topographic map of the United States, three different scales being recommended.

After discussion it was moved and carried that the Secretary be instructed to write Dr. Ashley that in the opinion of the Board of Direction the scale of 1:63,360 or 1 in. to the mile would be best adapted to the needs of the country and they recommended the use of this scale.

The Secretary presented a letter from Mr. James Guthrie, Chairman, The Liaison Committee, American Society of Mechanical Engineers, extending an invitation to our Society to participate in the regional meeting to be held in Cleveland, June 13th and 14th.

After discussion the Secretary was instructed to endeavor to locate members of our Society who expected to attend the meeting and ask them to act as our representatives.

Mr. Danforth reported that the House Bill No. 204, an Act licensing engineers in the State of Pennsylvania had finally passed both House and Senate and was up for signature of the Governor. Mr. Danforth stated further that copy of the bill had been promised him, but that he had not been able to secure it in time for the Board meeting.

It was suggested that the Bill be gone over by the Committee who represented the Society at the hearings in order that we might ascertain whether or not the recommendation of the Board had been included in the revised bill so that we might know if we wish the bill to pass as it stands.

The Secretary presented a letter from Mr. U. N. Arthur, Secretary of the Pittsburgh Meeting, National Conference on City Planning to be held May 9th, 10 and 11th in the William Penn Hotel, extending a cordial invitation to members of the Society to attend the meetings of the Conference.

It was moved and carried that the Secretary be instructed to write to the Secretary of the Conference extending an invitation to members of the Conference to make use of the Society Rooms during their stay in Pittsburgh.

On motion the meeting adjourned at 5:30 P. M.

K. F. Treschow, *Secretary.*

CIVIL SECTION.

The regular bi-monthly meeting of the Civil Section of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday, May 5th, at 8:20 P. M., Chairman Louis P. Blum presiding, 22 members and visitors being present.

The Minutes of the last meeting, held March 8th, were read and approved.

There being no further business before the Section, the paper of the evening on "The Miles Acid Process of Sewage Treatment," was presented by Dr. E. W. Mohlman, Chief Chemist, Sanitary District of Chicago, Chicago, Ill.

Written discussion was received from: W. L. Stevenson, Ass't. Chf. Engr., Department of Health, Harrisburg, Pa.

The ensuing discussion was participated in by: A. E. Blake, Pittsburgh Representative, U. G. I. Contracting Co.; J. P. Leaf, City Engineer, Beaver Falls; H. R. Thayer, Markhart Thayer Engineering Co.; Louis P. Blum, Blum-Weldin & Co; A. Pinkerton, Electrical Engineer, American Sheet & Tin Plate Co; George H. Danforth, Struct. Engr., Jones & Laughlin Steel Co.; G. F. Maglott, Division Engr., Morris Knowles, Inc., and the author.

It was moved and seconded and passed unanimously that a vote of thanks be extended to Dr. Mohlman for his very interesting paper.

On motion the meeting adjourned at 10:05 P. M.

K. F. Treschow, *Secretary.*

REGULAR MONTHLY MEETING.

The 395th meeting of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday, May 17th, at 8:15 P. M., President George H. Danforth presiding, 71 members and visitors being present.

The Minutes of the last meeting held April 19th, were read and approved.

The Board of Direction reported the election of fifty-five applicants to the grade of Member, thirty-three to the grade of Associate Member and thirteen to the grade of Junior, and the receipt of eleven applications for membership. One resignation and two deaths reported.

No further business coming before the Society, the paper of the evening was presented by Mr. George L. Morehead, Manager, Link Belt Company, Indianapolis, Ind. on "Description of the Manufacture of Elevating, Conveying and Power Transmission Chains."

The ensuing discussion was participated in by: J. M. Rice, Cons. Engr., Pittsburgh, Pa.; L. F. W. Hildner, V. P. & Chf. Engr., Pittsburgh Bridge & Iron Works; T. Frank Webster, Dist. Mgr., Link Belt Co.; A. G. Ahrens, Sales Engr., Westinghouse Elec. & Mfg. Co.: C. F. Freeman, Sales Engr., Surface Combustion Co.; George H. Danforth, Struct. Engr., Jones & Laughlin Steel Co.; W. C. Buell, Jr., Chf. Engr., Liquid Fuel Dept., George J. Hagan Co.; P. P. Krepp. Engr., Universal Steel Co.; A. M. Austin, Elec. Engr., Westinghouse Elec. & Mfg. Co.; E. O. Mueller, Engr., Pittsburgh, Pa.; G. W. Thomas, Asst. Engr., Duquesne Slag Products Co.; and the author.

On motion a vote of thanks was extended to Mr. Morehead for his very excellent paper.

On motion the meeting adjourned at 10:15 P. M.

K. F. Treschow, *Secretary*.

BOARD OF DIRECTION

The regular monthly meeting of the Board of Direction of the Engineers' Society of Western Pennsylvania was held in the Society Rooms, Union Arcade Bldg. Thursday June 2nd at 4:30 P. M. President George H. Danforth presiding. Messrs James, Spellmire, Schatz, Fohl, Hildner, Hunter, Nelson, [illegible] [illegible] Long, Stucki, Davis and the Secretary being present.

The minutes of the last regular meeting held May 5th were read and approved.

The applications of the following gentlemen having been regularly published to the Society pursuant to the action of the Board, were elected to Membership.

MEMBERS

Andrews, William W.
Crane, J. B.
Dunham, B. W.
Haslam, E. E.
Johnson, Samuel M.
McCabe, H. Dallas
McKnight, William Espy
Murphy, George F.
Uhlenhaut, Jr. Fritz.

ASSOCIATE MEMBER

Orr, N. H.

ASSOCIATE

Shaw, Hugh Campbell

The applications of the following gentlemen were received and their names ordered published to the Society. Assignment to the various grades of membership is as follows:

MEMBERS

Bjornson, Edwin
Corbett, Robert Lee
Donnan, David M.
Evans, Roger McCune
Joy, Joseph Francis
Shelley, Henry T.

ASSOCIATE MEMBERS

Barton, H. E. R.
Doerr, Charles Wm.

JUNIORS

Coon, Mortimer F.
Stevens, Frank A.
Donaldson, Robert R. Jr.

STUDENT JUNIOR

Fohl, Charles Taylor

Requests were received from the following gentlemen, asking that they be transferred to the grade of Member. After discussion, the

Secretary was requested to write these gentlemen, advising that they have been transferred to the grade of Member.

Edgar, W. C. Bucher, Harold Follmer

Letters of resignation were received from the following gentlemen and after discussion they were ordered accepted.

Barton, C. R. Stickle H. W.

The report of the Secretary showing the financial condition of the Society at the close of business April 30th, having been previously audited by the Finance Committee, was approved.

Mr. Spellmire, Chairman of the Entertainment Committee reported that final arrangements had been made for the inspection trip through the Windsor Power Plant of the Beech Bottom Power Co. on June 4th. Also for the boat excursion on June 8th.

Preparation is being made for annual banquet in December and work is being done in selection of suitable speakers for the Banquet.

JOINT REPORT HOUSE AND FINANCE COMMITTEE

The accounts of the Society were audited and found to be correct.

The evening attendance for the month of May was 63.

The joint meeting of the House and Finance Committee was held Wednesday evening, June 1st, to discuss matters of quarters and the general financial condition of the Society.

This is the second meeting held and these matters have been discussed thoroughly with the result that the Committee wishes to recommend the calling of a special meeting of the Board of Direction at which they can appear and present certain recommendations.

It is their intention to send to each member of the Board before this meeting certain data which has been complied during this investigation in order that the Board might be thoroughly posted before coming to the meeting.

After discussion, it was moved and carried that a special meeting of the Board of Direction be called for Thursday, June 9th, at 6:00 P. M. and that the Secretary be instructed to make arrangements at some hotel for a private dining room where the members can take dinner and discuss the recommendations to be presented, by the committees.

The meeting adjourned at 4:55 P. M.

K. F. TRESCHOW, *Secretary.*

REGULAR MONTHLY MEETING

The 396th regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday, June 7th at 8:15 P. M., President George H. Danforth presiding, 66 members and visitors being present.

The Minutes of the last regular meeting held May 19th, were read and approved.

The Board of Direction reported the election of nine applicants to the grade of Member, one to the grade of Associate Member and one to the grade of Associate; two members transferred to the grade of Member and the receipt of two resignations.

The President announced the result of the Chess Tournament held in the Society Rooms during the past few weeks and called Mr. Stucki to receive the first prize, a beautiful silver vase filled with American Beauty roses.

Mr. Stucki: Vase, flowers and all? Gentlemen, this is a great pleasure to me. I have a good many flowers at home and I assure you that this beautiful vase will stand on the center of the table, daily honored by a fresh bouquet, and the inscription "Engineers' Society of Western Pennsylvania, Chess Tournament, 1921" will always be turned towards my chair.

Your President gave me credit for having played four hours and a half at one game. This is not to my credit, but rather belongs to my opponent and good friend, Mr. Thayer.

This token is dear to me for three reasons. First, it will continuously remind me of our good and worthy President, who, I understand, is the donor of the prize. Second, it links me permanently with our Society, already so dear to me, and in the third place, I appreciate that it is the first prize of the first chess tournament of the Engineers' Society of Western Pennsylvania.

It has been awarded to the most successful chess player in that contest, but that does not say by any means that he is the best player. On this occasion,. I want to say that a great many members of the Society (chess players and others), had much pleasure out of this tournament. It enlivened the club room and made it look like a real home. The Society certainly deserves a great deal of credit for keeping it open all the time, thereby giving the members a chance to enjoy our "Home Downtown" whenever we wished to, day or evening.

I thank you very much for this beautiful prize.

Mr. Danforth then called Mr. Thayer, Mr. Stucki's competitor, (who was able to keep the play going for four and one half hours) to receive the second prize, a set of ivory chess men, presented by the Federal Engineering Co.

Mr. Thayer: Mr. President and gentlemen, I wish to thank the donor of this prize, also the Secretary for the way in which he has worked up this little contest and made it enjoyable for us, as he always does things of this sort. I would also thank the Committee of Arrangements which gave me a nice little handicap. I do hope there will be other occasions of this kind, in which perhaps I shall not be quite so fortunate.

But, better than any physical value, I prize the good followship of this company and the friends we have made playing chess together in the rooms of the Society. And it seems to me the scope of this work should be broadened. Why not have other games, and why not larger quarters perhaps a building of our own, in which all technical and scientific societies could get together and where we could enjoy the benefits of a Club Room? Why not a building devoted to the engineers of this great industrial community and to the Engineers Societies? To my mind there is no better time than the present to put forward a project of this kind.

I thank you very much.

No further business coming before the Society, the paper of the evening on "The Developing of a Steel Salesman" was presented by Mr. A. E. Crockett, Manager, Bureau of Instruction, Jones & Laughlin Steel Co., Pittsburgh Pa.

The ensuing discussion was participated in by: W. W. Ewing, Special Representative Export Dept. Jones & Laughlin Co.; George H. Danforth. Structural Engr. Jones & Laughlin Steel Co.; A. Stucki, Cons. Engr. A. Stucki & Co.; H. R. Thayer, Markhart-Thayor Engineering Co,; J. O. Durkee, National Coal Association; E. O. Mueller, Engr. Pittsburgh; E. F. Forbath, Pgh. Mgr., Granite City Industrial & Development Co.; and the author.

On motion the meeting adjourned at 9:55 P. M.

K. F. Treschow, *Secretary.*

MECHANICAL SECTION

The regular bi-monthly meeting of the Mechanical Section of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday evening, June 14th at 8:15 P. M., Chairman J. C. Hobbs presiding, 78 members and visitors being present.

The minutes of the last regular meeting held April 5th, were read and approved.

No further business coming before the Section, the papers of the evening on "Some Technical Uses and Properties of Monel Metal" by

Mr. Robert J. McKay, Industrial Fellow, Mellon Institute, Pittsburgh, Pa. and "Calorizing as a Protection for Metals" by Mr. A. V. Farr, Mechanical Engineer, Calorizing Co. of Pittsburgh, were presented.

The ensuing discussion was participated in by: R. E. Butler, Engr, Babcock & Wilcox Co.; E. E. Espenschied, Pgh. Dist. Repr., Commercial Truck Co. of Philadelphia; A. C. Fieldner, Supt. & Supervising Chemist, Pittsburgh, Experiment Station, U. S. Bureau of Mines; L. G. Firth, Works Manager, Firth-Sterling Steel Co.; J. M. Hood, Chemist, Fort Pitt Malleable Co.; William J. Merten, Met. Engr. Westinghouse Elec. & Mfg. Co.; M. R. Walton, Chf. Engr., Firestone Steel Products Co., Akron, Ohio; and the author.

The meeting adjourned at 9:55 P. M.

K. F. Treschow, *Secretary.*

MINING SECTION

The regular bi-monthly meeting of the Mining Section of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday, June 28th, at 8:20 P. M., Mr. W. A. Weldin presiding in the absence of the chairman, 29 members and visitors being present.

The minutes of the last meeting held March 29th were read and approved.

There being no further business before the Section the paper of the evening on "Description of Mather Collieries Plant" was presented by Mr. J. R. Elliott of Baton & Elliott, Pittsburgh, Pa.

The ensuing discussion was participated in by: E. V. Braden, Engr. Pittsburgh, Chartiers & Youghiogheny Rwy. Co.; J. W. Rice, Consulting Engineer, Pittsburgh; W. A. Weldin, Blum-Weldin & Co.; and the author.

On motion the meeting adjourned at 9:25 P. M.

K. F. Treschow, *Secretary.*

BOARD OF DIRECTON.

The Regular monthly meeting of the Board of Direction of the Engineers' Society of Western Pennsylvania was held in the Society Rooms Union Arcade Bldg., Thursday, Sept. 1st, at 4:10 P. M., President George H. Danforth presiding, Messrs James, Schatz, Hunter, Fohl, Hawley, Hobbs, and the Secretary being present.

The Minutes of the last regular meeting held June 2nd and of the Special Meeting held June 30th were read and approved.

The applications of the following gentlemen having been regularly published to the Society, pursuant to the action of the Board, were elected to Membership.

MEMBERS

Bjornson, Edwin
Corbett, Robert Lee
Shelley, Henry T.
Donnan, David M.
Evans, Roger McCune
Joy, Joseph Francis

ASSOCIATE MEMBERS

Doerr, Charles William
Barton, H. E. R.

JUNIORS

Coon, Mortimer Fremont
Donaldson, Robert R. Jr.
Stevens, Frank A.

STUDENT JUNIOR

Fohl, Charles Taylor

The applications of the following gentlemen were received and their names ordered published to the Society. Assignment to the various grades of membership is as follows.

MEMBERS

Bazilevitch, Leonid V.
Butler, M. Bayard, Jr.
Ellwood, Orville Anderson
Karns, Edward Allan
Martin, Charles A.
Randolph, Dales Nicholas
Thatcher, Fent Edwin Napoleon
Trexler, Edwin W.
Wood, Eric Fisher

ASSOCIATE MEMBERS

Newell, Robert Edgar
Taylor, E. Clifford

ASSOCIATE

Maser, Henry E.

Request was received from Mr. J. B. Kaiser asking that he be transferred to the grade of Member. After discussion, the Secretary was requested to write Mr. Kaiser, advising that he had been transferred to the grade of Member.

Letters of resignation were received from the following gentlemen and after discussion they were ordered accepted.

Bissell, D. S.	Munroe, D. A.
Higgins, H. K.	Nyman, A.
Hibbin, S. G.	Paar, O. A.
Huntsman, C. R. Sr.	Rieseck, W. P.

The Secretary reported the death of the following members: C. W. Cade, G. Gudmundson, F. I. Kimball, A. H. Lauman, Jr., W. F. Purdy.

The reports of the Secretary showing the financial condition of the Society at the close of business May 31st, June 30th and July 31st, having been previously audited by the Finance Committee, were approved.

In connection with the above reports, the Secretary stated that Mr. Fohl, Chairman of the Finance Committee had asked him to call to the attention of the Board the matter of authorizing the Committee to use the $1200 in the Reserve Fund to tide over until the end of the year. It was pointed out that due to the fact that our Proceedings are behind in publication on account of the printers' strike, we had not been able to send out advertising bills for the first half of 1921. This has caused a shortage in receipts in August and has left very little money in the bank. The Committee sent out letters the first of September to all delinquent members hoping thereby to overcome this deficiency to some extent. However, as we will probably need this $1200 before the end of the year, it is suggested that the Board authorize the use of it in order to avoid the possibility of having to call a special meeting of the Board.

After discussion, it was moved and carried that the Finance Committee be authorized to use this $1200 when necessary.

COMMITTEE REPORTS.

Mr. Schatz, Chairman of the House Committee, reported an evening attendance of 35 for the month of July.

The Secretary reported further that Mr. Schatz has completed arrangements with the William Penn Hotel for the use of the room in the basement together with other details discussed at the special meeting of the Board last June. The Committee has also notified Mr. Shaw of the Frick Estate that we would like to be released by the first of October if possible, as we understand that they are making every effort to secure tenants for our present quarters. The William Penn Hotel has submitted a lease which is in our hands and will be signed as soon as we have been released by the Frick Estate.

In this connection Mr. Schatz also stated that the matter of a safe cabinet was taken up with Mr. Butler of the William Penn Hotel. who advised they would not be able to furnish us with a safe and it will, therefore, be necessary for the Society to purchase one. After discussion, it was moved and carried that the House Committee be authorized to purchase a safe as soon as the lease has been signed.

Mr. Spellmire, Chairman of the Entertainment Committee, reported that they had under consideration the Annual Banquet and had tentatively set the date of Monday evening, Jan. 23rd on which it is to be held. The Committee had in mind holding the Banquet in December, but owing to the condition of business at this time, it was deemed advisable to hold it in January.

Arrangements have also been made for several inspection trips this Fall, which are held up pending resumption of business. Seventy-five acceptances have been received for the trip on Saturday to the Government Locks and Dams at Emsworth.

The meeting adjourned at 5:15 P. M.

K. F. Treschow, *Secretary.*

REGULAR MONTHLY MEETING.

The 397th regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday, Sept. 20th, at 8:20 P. M., President George H. Danforth presiding, 72 members and visitors being present.

The Minutes of the last regular meeting held June 7th, were read and approved.

The Board of Direction reported the election of six applicants to the grade of Member; two to the grade of Associate Member; three to grade of Junior and one to the grade of Student Junior and the receipt of twelve applications for membership; also the transfer to higher grade of one member and the receipt of four resignations.

The President announced the appointment of the following nominating committee to nominate officers for the ensuing year.

George H. Neilson, *Chairman*
W. C. Buell, Jr.
A. E. Crockett
G. E. Flanagan
H. M. Wilson

There being no further business coming before the Society, the paper of the evening on "Contact Catalysis" was presented by Prof. W. D. Bancroft, Professor, Chemical Engineering, Cornell University, Ithaca, N. Y.

The ensuing discussion was participated in by: A. E. Blake, Pgh. Representative, U. G. I. Contracting Co; J. B.Crane, Engineer, George T. Ladd Co.; J. F. Babb, Supt. & Director, Chemical Laboratory, Waverly Oil Works Co.; K. F. Stahl, Consulting Chemist, Pittsburgh, Pa.; F. F. Espenschied, Pgh. District Representative, Commercial Truck Co. of Philadelphia; A. C. Fieldner, Supt. & Supervising Chemist, Pittsburgh Experiment Station, U. S. Bureau of Mines; and the author.

Mr James O. Handy moved that a vote of thanks be extended to Prof. Bancroft for his very excellent paper, which was seconded and carried unanimously.

On motion the meeting adjourned at 9:55 P. M.

K. F. Treschow, *Secretary*.

PRACTISING ENGINEERS' SECTION.

A meeting of the Practising Engineers' Section of the Engineers' Society of Western Pennsylvania was held in the Society Rooms, Union Arcade Bldg., Wednesday, evening, Sept. 21st, at 6:30 P. M., Chairman C. E. Long presiding, ten members being present.

The Minutes of the last meeting held June 22nd, were read and approved.

The Chairman called for the report of the Committee on Compensation and Mr. Ross reported that all of the Sub-Committees had not yet sent in their reports and the General Committee, therefore, were unable to prepare a preliminary report for presentation.

Mr Ross stated that it was his intention to call the Chairman of the Sub-Committees together within the next week and they would be in position to make a final report at the October meeting of the Section.

After a general discussion on this subject, the meeting adjourned at 8:15 P. M.

K. F. Treschow, *Secretary*.

BOARD OF DIRECTION

The regular monthly meeting of the Board of Direction of the Engineers' Society of Western Pennsylvania was held in the Society Rooms, Union Arcade Building, Thursday, October 6th at 4:15 P. M., President George H. Danforth presiding, Messrs. James, Spellmire, Hunter, Fohl, Neilson, Hawley Hildner, Blum and the Secretary being present.

The Minutes of the last meeting held September 1st, were read and approved.

The applications of the following gentlemen, having been regularly published to the Society, pursuant to the action of the Board, were elected to membership.

MEMBERS

Bazilevitch, Leonid V.
Butler, M. Bayard, Jr.
Ellwood, Orville Anderson
Karns, Edward Allan
Martin, Charles A.
Randolph, Charles Nicholas
Thatcher, Fent Edwin Napoleon
Trexler, Edwin W.
Wood, Eric Fisher

ASSOCIATE MEMBERS

Newell, Robert Edgar
Taylor, E. Clifford

ASSOCIATE

Maser, Henry E.

The applications of the following gentlemen were received and their names ordered published to the Society. Assignment to the various grades of membership is as follows:

MEMBERS

Anderson, David P.
Friederici, Max
Hadley, Edward Thomas
Heinle, Albert Werneberg
Shaw, William

JUNIORS

Fowler, Warren Glenn
Snyder, Lester Charles.

Letters of resignation were received from the following gentlemen and after discussion, they were ordered accepted: E. Blough, D. Elder.

The report of the Secretary showing the financial condition of the Society at the close of business August 31st, having been previously audited by the Finance Committee, was approved.

Mr. Spellmire, Chairman of the Entertainment Committee, reported that plans are being perfected for the Annual Banquet, looking toward securing desirable speakers. A meeting will probably be held within the next week, the result of which will be favorable toward a more complete report at the next meeting.

Mr. Schatz, Chairman of the House Committee, reported an evening attendance of 49 for the month of September. The Secretary reported verbally that the House Committee had been in communication with Mr. Shaw, who stated that they would make every effort to find tenants for our present quarters, but had not been able to do so up to the present time. The lease for the William Penn quarters is still in our hands unsigned.

Mr. J. A. Hunter, Chairman of the Membership Committee, reported that the Committee has held one meeting during the past month at which time there was a general discussion of the possibilities of increasing our membership. Two or three plans were suggested and it is our intention to carry them out within the next three months.

The Secretary presented the following report from the Medal Awards Committee for the year 1920, and after discussion it was moved and carried that the Silver Medal be awarded to each of the authors. The Secretary was instructed to purchase these medals.

September 28, 1921.

Board of Direction,
Engineers Society of Western Pennsylvania:

Dear Sirs:

The Medal Awards Committee for the year 1920 respectfully reports as follows:

Your Committee is of the opinion that none of the papers presented was of the high quality necessary for award of a gold medal.

We believe that the best paper presented during the year was that entitled "Regional Planning in the Pittsburgh District" by Messrs. Morris Knowles and Maurice R. Scharff. Your Committee, however, finds itself in this difficulty. The rules governing the award of medals do not seem to have considered the dual authorship of a paper and the award of more than one medal for such a paper. We believe that this paper by Messrs. Knowles and Scharff is entitled to the award of a silver medal, but we respectfully refer to the Board the question as to whether each author should receive a medal or whether one medal should be issued to the two authors or whether, under the rules governing the award, no medal can be given.

Very respectfully,

W. C. Hawley,
W. E. Fohl,
John A. Hunter,
Committee.

On motion the meeting adjourned at 5:15 P. M.

K. F. Treschow, *Secretary.*

MECHANICAL SECTION

The regular bi-monthly meeting of the Mechanical Section of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, on Tuesday evening, October 4th, at 8:15 P. M. Chairman, J. C. Hobbs presiding, 205 members and visitors being present.

The Minutes of the last regular monthly meeting held June 14th were read and approved.

There being no further business before the Section, the paper of the evening on Power Station Design was presented by Mr. C. W. E. Clark, Power Engineer, Dwight P. Robinson Co., New York, N. Y.

Written discussion was received from F. M. VanDeventer, Engr., Power Dept, National Tube Co.; G. G. Bell, Mgr., Power Generating Dept., West Penn Power Co.

The ensuing discussion was participated in by John A. Hunter, Steam and Sanitary Engr., American Sheet & Tin Plate Co.; F. J. Crolius, Steam

Engr., Homestead Steel Works, Carnegie Steel Co.; F. F. Espenschied, Pittsburgh Dist. Repr., Commercial Truck Co. of Philadelphia, and the author.

On motion the meeting adjourned at 10:35 P. M.

K. F. TRESCHOW, *Secretary.*

CIVIL SECTION

The regular bi-monthly meeting of the Civil Section of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday, October 11th, at 8:10 P. M. President George H. Danforth presiding in the absence of Mr. L. P. Blum, Chairman, 105 members and visitors being present.

The Minutes of the previous meeting held May 3rd, were read and approved.

There being no further business coming before the Section, the paper of the evening was presented by Mr. J. L. deVou, Division Erection Manager, American Bridge Co., Pittsburgh, Pa., on "The Erection of the 33rd Street Allegheny River Crossing of the B. & O. R. R. at Pittsburgh."

The ensuing discussion was participated in by: L. F. W. Hildner, V. P. and Chf. Engr., Pittsburgh Bridge & Iron Works, Pittsburgh; C. N. Haggart, Structural Engineer, Pittsburgh; N. S. Sprague, Consulting Engineer, Pittsburgh; E. W. Stearns, Representative, John E. Griener & Co., Pittsburgh, and the author.

On motion the meeting adjourned at 9:30 P. M.

K. F. TRESCHOW, *Secretary.*

REGULAR MONTHLY MEETING

The 398th regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday, October 18th, at 8:13 P. M., President George H. Danforth presiding, 59 members and visitors being present.

The Minutes of the last regular meeting held September 20th, were read and approved

The Board of Direction reported the election of nine applicants to the grade of Member, two to the grade of Associate Member and one to the grade of Associate and the receipt of seven applications for membership and the receipt of two resignations.

There being no further business the paper of the evening on "The Nature of Brass" was presented by Dr. A. E. White, Director, Colleges of Engineering & Architecture, University of Michigan, Ann Arbor, Mich.

Written discussion was received from D. D. Pendleton, Sales Engr., Wheeler Condenser & Engineering Co., Pittsburgh.

The ensuing discussion was participated in by: W. J. Merten, Research Engr., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.; T. D. Lynch, Research Engr., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.; Max Hecht, Chf. Chemist, Chemical Laboratory, Duquesne Light Co., Pittsburgh, and the author.

On motion duly approved and seconded, a vote of thanks was extended to Dr. White for his very excellent paper.

On motion the meeting adjourned at 10:03 P. M.

K. F. TRESCHOW, *Secretary.*

STEEL WORKS SECTION

The regular bi-monthly meeting of the Steel Works Section of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday, October 25th, at 8:15 P. M., Chairman T. P. Davies presiding, 82 members and visitors being present.

The Minutes of the last meeting held April 26th, were read and approved.

There being no further business coming before the Section, the paper of the evening by Dr. C. M. Stein, Engineer, Paris, France, was read by Mr. W. B. Chapman, President of the Chapman Engineering Co., New York in the absence of Dr. Stein, on "Heating Furnaces—Design and Practice."

The ensuing discussion was participated in by: W. C. Buell, Jr., Chf. Engr., Liquid Fuel Dept., George J. Hagan Co.; M. Bayard Butler, Jr., General Manager Mines, Hanlan Coal Co., Brownsville, Pa.; W. Trinks, Professor Mechanical Engineering, Carnegie Ins. of Technology; C. F. Freeman, Sales Engr., Surface Combustion Co.; D. L. Mekeel, Chf. Engr., Jones & Laughlin Steel Co.; A. E. Blake, Pittsburgh Representative, U. G. I. Contracting Co.; Walter DeFries, Engr. Development Dept., Blaw-Knox Co., and Mr. Chapman, in the absence of the author.

On motion, duly seconded and carried a vote of thanks was extended to Mr. Chapman and Dr. Stein for the very excellent paper presented.

On motion the meeting adjourned at 10:15 P. M.

K. F. TRESCHOW, *Secretary.*

BOARD OF DIRECTION.

The regular monthly meeting of the Board of Direction of the Engineers' Society of Western Pennsylvania was held in the Society Rooms, Union Arcade Building, Thursday, November 3rd, at 4:10 P. M., President George H. Danforth presiding Messrs. James, Stucki, Fohl, Schatz, Hunter, Hawley, Hildner, Blum, Hobbs, and the Secretary being present.

The Minutes of the last regular monthly meeting held October 6th, were read and approved.

The applications of the following gentlemen having been regularly published to the Society, pursuant to the action of the Board, were elected to membership.

MEMBERS

Anderson, David P.
Friederici, Max
Hadley, Edward Thomas
Heinle Albert Werneberg
Shaw, William

JUNIORS

Fowler, Warren Glenn
Snyder, Lester Charles

The applications of the following gentlemen were received and their names ordered published to the Society. Assignment to the various grades of membership is as follows:

MEMBERS

Stone, Lauson
Tellin, William G.

ASSOCIATE MEMBER

Jackson, Ray Philip

Request was received from Mr. Herman C. Ihsen, asking that he be transferred to higher grade of membership. After discussion, the Secretary was requested to write Mr. Ihsen, advising him that he had been transferred to the grade of Member.

Letters of resignation were received from the following gentlemen and after discussion, they were ordered accepted.

Heisley, Frederick W. Joined June 1915.
Schuttler, Carl H. Joined May 1918.
Stickel, C. R. Joined December 1915.
The Secretary reported the death of the following members.
Allen, Hugh P. Joined May 1920, Died October 1921.
Whittaker, Lee Joined January 1880.

The report of the Secretary showing the financial condition of the Society at the close of business September 30th, having been previously audited by the Finance Committee was approved.

The House Committee reported an evening attendance of 79 for the month of October. The Secretary reported verbally stating that the

Frick Estate had succeeded in renting the two rooms, 568 and 569 and had released us from these rooms and allowed us a credit of $122.00 per month on our present lease.

They also presented a proposition to Mr. Schatz stating that in view of the fact that they were paying $120.00 per month to the William Penn Hotel for the use of the Blue Room for our meetings, if we would release them from this obligation by moving into the William Penn Hotel. they would agree to credit us with this $120.00 leaving a balance of $25.00 per month on our present lease. This would in turn be cancelled as soon as they found it possible to lease the balance of our quarters. Mr. Schatz stated that after going into the matter carefully it had been decided to accept this proposition as it was felt the Frick Estate could not afford to let these rooms remain idle at $25.00 per month very long and in all probability we would only be compelled to pay one, or at the outside two months rent at this price.

The Committee then finally went over the lease submitted by the William Penn Hotel and several corrections suggested and the lease returned to Mr. Butler. As soon as these have been made, we are in a position to sign and move our quarters to the hotel. Mr. Schatz stated further, that in view of the present condition of our finances, he would be very glad to assume for the present the responsibility of the rent due the Union Arcade and the first month's rent in the new quarters, if agreeable to the Board.

Report of Nominating Committee.

October 31, 1921.

To the Board of Direction
Engineers' Society of Western Pennsylvania,

Dear Sirs:

At the meeting of the Nominating Committee of the Engineers' Society of Western Pennsylvania held in the Society Rooms, Union Arcade Building, Monday, October 31st. at 4:00 P. M. the following gentlemen were unanimously chosen for the respective offices indicated below:

For President..........Henry D. James
For Vice President..........Frederic Crabtree
For Treasurer..........A. Stucki
For Directors..........J. C. Hobbs
C. D. Terry

Respectfully submitted,

Nominating Committee
George H. Neilson, *Chairman*,
Arthur E. Crockett,
H. M. Wilson,
G E. Flanagan,
W. C. Buell, Jr.

It was moved and carried that the report be approved and the Secretary instructed to publish the names to the Society in accordance with the By-Laws.

On motion the meeting adjourned at 5:40 P. M.

K. F. Treschow, *Secretary*.

CIVIL SECTION.

The regular bi-monthly meeting of the Civil Section of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday, November 8th at 8:15 P. M., 78 members and visitors being present.

The Minutes of the last meeting held October 11th, were read and approved.

There being no further business coming before the Section the paper of the evening was presented by Mr. Winters Haydock, Engineer, Citizens Committee on City Plan of Pittsburgh, Pittsburgh, Pa. on "The Traffic Count of Pittsburgh."

The ensuing discussion was participated in by: L. P. Blum, Blum-Weldin & Co.; James Craven, Craven Research Laboratories, Pittsburgh; E. F. Espenschied, Pgh. Dist. Repr., Commercial Truck Co. of Philadelphia, Pittsburgh; John A. Ferguson, Secy-Engr., Building Code Committee, City of Pittsburgh; C. E. Long, Civil Engr., Pittsburgh; J. B. Mandeville, Chf. Engr., T. W. Phillips Gas & and Oil Co., Butler, Pa.; Paul C. Merz, Cons. Engr., Pittsburgh; C. S. Palmer, Consulting Chemical Engineer, Pittsburgh; P. W. Price, Asst. Engr., County Engineer's Office, Pittsburgh; J. M. Rice, Cons. Engr., Pittsburgh; C. L. Wooldridge, Gen. Supt., Carnegie Land Company, and the author.

On motion duly seconded and carried a vote of thanks was extended to Mr. Haydock for his very excellent paper.

Meeting adjourned at 10:12 P. M.

K. F. TRESCHOW, *Secretary.*

REGULAR MONTHLY MEETING.

The 399th regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday, November 15th, at 8:23 P. M. President George H. Danforth presiding, 420 members and visitors being present.

The Minutes of the last regular meeting held October 18th were read and approved.

The Board of Direction reported the election of five applicants to the grade of Member, two to the grade of Junior and the receipt of three applications for membership. Also the transfer of one member to higher grade and receipt of three resignations. Two deaths were reported.

There being no further business coming before the Society the paper of the evening was presented by F. H. Kroeger, Engineering Dept., Radio Corporation of America, New York on "Recent Developments in Radio Telegraphy and Telephony".

After the reading of the paper a demonstration of radio-telephony was given by the Double-Day-Hill Electric Co.

The ensuing discussion was participated in by: Walter B. Spellmire, Mgr., General Electric Co., Pittsburgh; W. H. Jackson, Pres., Pittsburgh-DesMoines Steel Co., Pittsburgh; R. C. Corderman, Engr., Pittsburgh; and the author.

On motion, duly seconded and carried, a vote of thanks was extended to Mr. Kroeger and also to the Double-Day-Hill Electric Co. for their contributions to the evening's entertainment.

On motion the meeting adjourned at 10:30 P. M.

K. F. TRESCHOW, *Secretary.*

PRACTISING ENGINEERS' SECTION.

The regular monthly meeting of the Practising Engineers' Section of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday, November 22nd, at 8:00 P. M.

The minutes of the last regular meeting held October 26th were approved without reading.

No further business coming before the Section, the paper of the evening on "A Major Street Plan for Pittsburgh" was presented by Mr. C. L. Wooldridge, General Superintendent, Carnegie Land Co., Pittsburgh.

The ensuing discussion was participated in by: Winters Haydock, Chief Engineer. Citizens' Committee on City Plan of Pittsburgh; P. W. Price, Asst. Engineer, County Engineers' Office; R. L. Smith, Civil Engineer, Private Practice, Pittsburgh; J. G. Sylvius, Member Board of Viewers, Allegheny County, Pittsburgh; C. M. Reppert, Chief Engineer, Bureau of Engineering, City of Pittsburgh; F. B. Chalfant, Div. Engineer, Div. Surveys, City of Pittsburgh, Pittsburgh; J. W. Rice, Consulting Engineer, Pittsburgh; Frederick Bigger, Secy., Citizens' Committee on City Plan of Pittsburgh; S. S. Davis, Bridge Engr., Jamison & Abbott, Architects; W. M. Austin, Electrical Engineer, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa; and the author.

On motion the meeting adjourned at 10:10 P. M.

K. F. Treschow, *Secretary*.

MINING SECTION.

The bi-monthly meeting of the Mining Section of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday, Nov. 29th, at 8:15 P. M. Mr. W. A. Weldin presiding in the absence of the Chairman and Vice Chairman, 49 members and visitors being present.

The minutes of the last meeting held June 28th were read and approved.

No further business coming before the Section, the paper of the evening on "The Lynch Plant of the United States Coal & Coke Co." was presented by Mr. Howard N. Eavenson, Consulting Mining Engineer, Howard N. Eavenson and Associates, Pittsburgh, Pa.

The ensuing discussion was participated in by: E. O. Mueller, Mgr., Pittsburgh Office, Pittsburgh Wire Rope Co.; Elmer F. Forbath, Engr., Pittsburgh; F. A. McDonald, Chf. Engr. & Gen. Supt., National Mining Co., Morgan, Allegheny Co. Pa.; L. S. Franklin, Mining Engr., Pittsburgh; F. W. Williams, Mining Engr., Pittsburgh; W. A. Weldin, Blum-Weldin & Co.; Mr. Duncan, Mining Engr., Pittsburgh; and the author.

On motion the meeting adjourned at 10:10 P. M.

K. F. Treschow, *Secretary*.

BOARD OF DIRECTION

The regular monthly meeting of the Board of Direction of the Engineers' Society of Western Pennsylvania was held in (Parlor "C",) William Penn Hotel, Thursday, Dec. 1st, at 4:10 P. M. President George H. Danforth presiding. Messrs. James, Knowles, Stucki, Schatz, Fohl, Neilson, Hawley, Hobbs and the Secretary being present.

The Minutes of the last regular meeting held Nov. 3rd were read and approved.

The applications of the following gentlemen having been regularly published to the Society, pursuant to the action of the Board, were elected to membership.

MEMBERS

Stone, Lauson
Tellin, William G.

ASSOCIATE MEMBER

Jackson, Ray Philip

The applications of the following gentlemen were received and their names ordered published to the Society. Assignment to the various grades of membership is as follows:

MEMBERS

Bruner, William J.
Forbath, Elmer F.

JUNIOR

Lundgren, E. H.

Letters of resignation were received from the following members and after discussion, they were ordered accepted: Townsend, H. W.; Braun, H. S.; Harrison, A. B. and Manice de Forest.

The Secretary reported the death of one of our oldest members Mr. F. Z. Schellenberg who joined the Society in February, 1882 and died Nov. 15, 1921. It was moved and carried that the Secretary be requested to write Mr. W. A. Weldin to ask if he would prepare a memoir of Mr. Schellenberg.

The report of the Secretary showing the financial condition of the Society at the close of business October 31st, was held over until next meeting, as owing to the removal of our quarters to the William Penn Hotel, the Secretary was unable to make up the statement.

COMMITTEE REPORTS.

Mr. Spellmire, Chairman of the Entertainment Committee, sent in written report, owing to his absence from the city, stating that Mr. George S. Davison, President, Gulf Refining Co. was to act as Toastmaster at the Annual Banquet. Much difficulty has been encountered in securing desirable speakers. About six very prominent men in the United States have been interviewed with varying degrees of success—largely negative.

Mr. Spellmire, while in New York on Thursday, will call on the Chairman of the Board of a very large steel manufacturer and has reason to be quite hopeful as to results. It is hoped that the entire program for the banquet may be presented at the next meeting.

The Secretary reported verbally on behalf of the Finance Committee. stating that four replies had been received from the Board of Direction taking out a life membership and three from the past presidents of the Society.

All bills for November were paid with the exception of $113.00 which had to be held over. This includes the payment of rent to the Frick Estate for October and only leaves a balance of $25.00 for November and $25.00 for December. Also $150.00 due the William Penn Hotel for rent from Nov. 15th. This leaves us a balance in the bank of about $25.00 and means we will have to collect enough in December to meet December bills.

On behalf of the House Committee the Secretary reported an evening attendance of 47 for the month of November.

As mentioned in the last minutes of the Board of Direction, the House Committee had accepted the proposition of the Frick Estate to release them from paying for the Blue Room in the William Penn Hotel and for the amount credited on our quarters in the Union Arcade Bldg. leaving us a liability of $25.00 per month.

The lease had been returned to Mr. Butler, Manager of the William Penn with suggested changes. However, the William Penn refused to include said changes but stated verbally that they would see that our requirements would be given prompt attention. Mr. Speller, a member of the House Committee, also took the matter up with Mr. Allderdice, who is a director of the Pittsburgh Hotels Co. who stated that if we encounter any difficulties he would be glad to aid us in any way possible. It was, therefore, decided to sign the lease for a period of two years and our quarters were moved the latter part of last week and we have found, up to this time, that Mr. Butler has been very willing to cooperate with us. This lease includes the leasing of the Blue Room forty evenings per year and a private room for our Board meetings.

The Secretary reported verbally on behalf of the Membership Committee, stating that due to the removal of our quarters and to the fact that he had been out of the city on matter of the banquet speakers and to the illness of Mr. Hunter, no progress had been made on the plans of the committee. However, they hope to take definite steps along these lines before the next meeting of the Board.

The report of the Nominating Committee nominating officers for the ensuing year was finally approved in accordance with the By Laws of the Society.

The meeting adjourned at 5:10 P M.

K. F. Treschow, *Secretary.*

REGULAR MONTHLY MEETING

The 400th regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday, December 20th at 8:07 P. M., President George H. Danforth presiding, 47 members and visitors being present.

The Minutes of the last regular meeting held November 15th were read and approved.

The Board of Direction reported the election of two applicants to the grade of Member and one to the grade of Associate Member and the receipt of three applications. Four resignations were accepted and one death reported.

Mr. Danforth announced that no gold metals had been awarded this year, but that two silver ones were awarded to Mr. Morris Knowles and Mr. M. R. Scharff for their joint paper on "Regional Planning in the Pittsburgh District" and were presented to these gentlemen.

No further business coming before the Society the paper of the evening on "Construction of the Monongahela River Bridge at Fairmount W. Va." was presented by Mr. S. L. Fuller, Chief Engineer, The John F. Casey Co.

The ensuing discussion was participated in by: V. R. Covell, Deputy County Engr., Allegheny County; J. D. Stevenson, Asst. Div. Engr., Bureau of Engineering, Div. of Bridges, City of Pittsburgh; K. L. Kortland, Designing Engr., Carnegie Steel Co., Duquesne, Pa.; W. M. Austin, Elec. Engr., Westinghouse Elec. & Mfg. Co.; V. Enebuske, Engr., The Foundation Co.; C. S. Davis, Cons. Bridge Engr., Pittsburgh; E. H. Haslam, Civil & Hydr. Engr., Pittsburgh; and the author.

On motion the meeting adjourned at 10:16 P. M.

K. F. TRESCHOW, *Secretary.*

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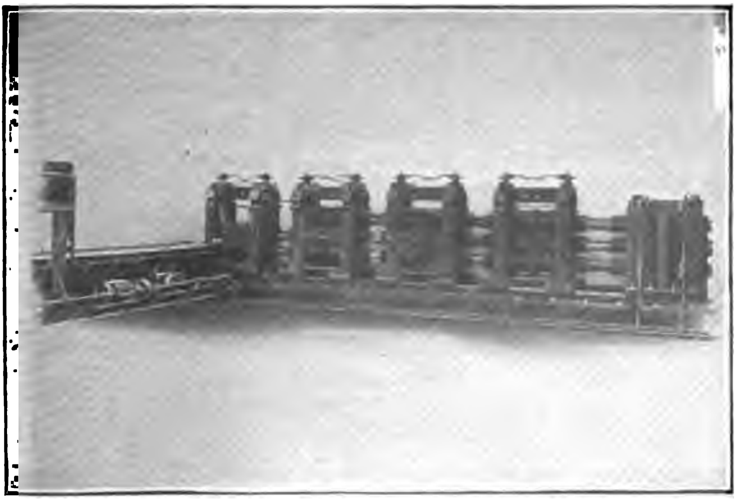

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